Flight

First Aero Weekly in the World.

A Journal devoted to the Interests, Practice, and Progress of Aerial Locomotion and Transport.

OFFICIAL ORGAN OF THE AERO CLUB OF THE UNITED KINGDOM.

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Bushey House, Teddington, the headquarters of the new Government Flight Office and home of the National Physical Laboratory over which Dr. R. T. Glazebrook, F.R.S., is Director. The lower picture is a view of the engineering laboratories at Bushey House over which Dr. T. E. Stanton, M.I.C.E., is Superintendent.

OPENING OF THE SPORTING SEASON.

THE International Balloon Race organised by the Aero Club of the United Kingdom starts from Hurlingham this afternoon. In a sense this event inaugurates the sporting season of 1909 in respect of aeronautics. It is befitting, too, that lighter-than-air craft, void of any mechanical equipment and drifting at the will of the wind, should alone figure in the competition, because it serves to remind us of the beginning of man's invasion of the realms of mid-air. His conquest has been along two independent lines of research, and by far the most familiar to date has been the exploitation of vessels that are lighter-than-air. Save in point of date, the balloons that will figure in this afternoon's friendly international rivalry will be very little removed from the machines that began to be evolved soon after the days of Montgolfier. Yet the science of human flight has gone forward a great stage during the interval.

The Aero Club of the United Kingdom does well in not casting off its old love while in the pursuit of the new. With the magnificent flying ground at Shellbeach its severest critic cannot truthfully contend that the Club is not first by a long way in the practical exploitation of aeroplanes in Britain. No rival body can ask for a hearing on any such line of argument. But, hand in hand with the laudable enterprise at Sheppey, we find the Club working to secure for the pastime of ballooning that popularity which it merits. As sports go it is quite one of the safest, while for variety of experience it is hard to equal. It is almost unique among sports, too, in being absolutely clean and noiseless. A lady need not fret, subject to protection from moisture, about wearing the daintiest frock when she steps into the basket of a balloon, which, once launched in air, is assuredly the completest means of enabling one to gaze on the world we live in as on a strange place. That sense of detachment, not bereft of security, which we enjoy when making an aerial voyage by balloon is not the least charming of the many experiences vouchsafed. The day may yet come when the fashionable doctor of Harley Street will prescribe ballooning as a part of the essential course of treatment in connection with rest cures. Nothing can be less exciting or more utterly restful than floating placidly through and above the clouds in fine weather.

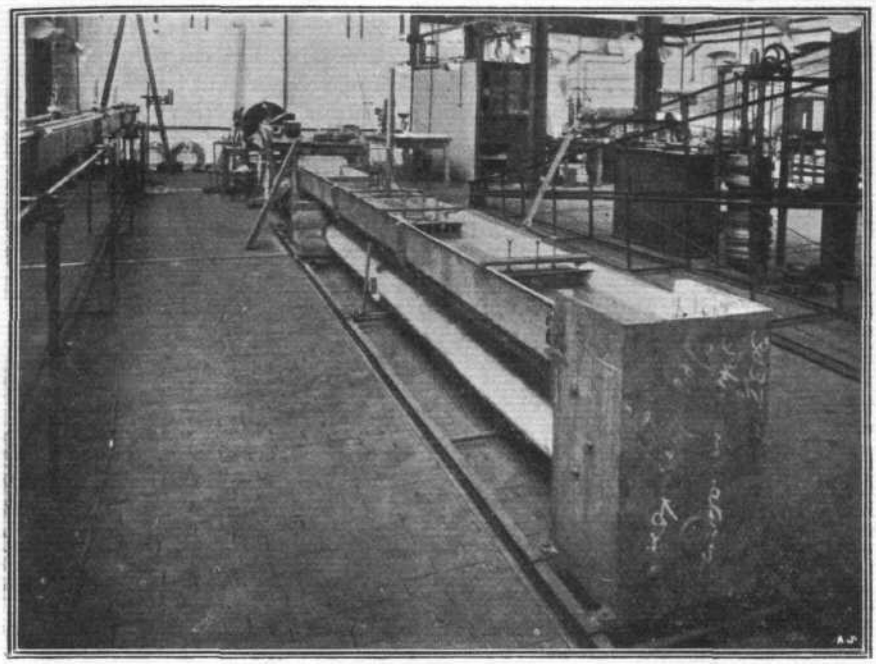
Such is what we may style the established sport in flight at the moment. As yet the dirigible is not in evidence among us save for military uses, as at Aldershot. But in France it has already been tried with encouraging results, and it is not unlikely that next year there may be formed quite a coterie of users of small dirigibles, with which an entirely different class of sport will be enjoyed.

The work which the Aero Club has in hand at Shellbeach is sport of a more strenuous and scientific character. Everything that can be done to render it attractive is being done. The ground is as good as anything available in these islands, and out and away better than a great number of the aeroplane grounds of France. The situation in regard to London must be deemed quite reasonably convenient, for the route by road is very pretty and can be traversed in approximately three hours, while, by catching the boat express train from Victoria, one can be on the flying ground in less time and at very little expense, for the Club has arranged special facilities for members whereby first class return railway tickets available for one month are issued to them for 8*s*. each; second class at 6*s*. 6*d*., and third class for 5*s*. Nobody can argue that this is a prohibitive price, especially in view of the fact that the ground is situated in such a bracing spot that if there were no aeroplaning to be seen at all it is good to spend a week-end thereabouts. The Club has been very fortunate in securing the old-world and picturesque house that was illustrated in last week's issue of FLIGHT, and in having a ground that, apart from being well-nigh ideally suited for aeroplaning, provides facilities for enjoying quite a number of other sports, including golf; and is uncommonly handy for enjoying sea-bathing. Indeed, there are a variety of reasons why during the coming season Sheppey is likely to become a very popular week-end resort among those interested in flight. In a little while we shall have the first essays to win some of the many prizes for performances of flying machines that are open under the auspices of the Aero Club of the United Kingdom. Those of us who are members of the Club are aware already of the bright prospects that are in store there for development in the immediate future of the movement. At the moment the public at large has no guess of all the preparations that are being made, but has merely had a hint from some reported utterances of Messrs. Wilbur and Orville Wright concerning the suitability of the ground. Therefore, in a few weeks time, when accounts of actual flights shall begin to filter through into the daily papers, it will come as something of a surprise to the general public that such extensive and serious preparations have been made for carrying on the movement in the "Isle of Sheep."

The enterprise of the Aero Club bears evidence of doing as much as that body can be reasonably expected to do to remove the reproach that in matters of flight we are behindhand in England. We look forward confidently to the opening season to furnish proof in abundance to the general public that at least a section of the British community is very much alive to the reality and possibilities of artificial flight, and, whatever may be said concerning absence of encouragement or facilities, that a body of real sportsmen has succeeded in creating facilities for itself and in making occasions for real progress in the science of using heavier-than-air flying machines. It is over a fortnight since the ground was first soared over by a flying machine. Now that Mr. Moore-Brabazon has got the "Bird of Passage" repaired there is every reason to look confidently forward to his leading the way with a series of fine flights, some of which, it is hoped, will secure for him certain of those prizes which have been offered for achievements well within his known powers of performance. Once start the vogue and there will be no difficulty in keeping it going. A promising feature of the sporting season now opening is that not one particular type of machine alone will be exploited on the grounds of Sheppey, as has been too often the case on French flying grounds, but several sorts of machines will be tried. At the moment at least five varieties are in hand and are expected to be completed within a reasonably short time. That is what we want, for we are only on the threshold of real developments and are merely beginning to learn the first things about flying. Hence the need for variety of enterprise and investigation, not conducted secretly, but in such a manner that effort shall not be wasted and real progress may be made with due speed. The sporting season that is opening is alike the most noteworthy and the brightest of any in the history of Britain.

THE NEW GOVERNMENT FLIGHT OFFICE AND HOME OF THE NATIONAL PHYSICAL LABORATORY, BUSHEY HOUSE.

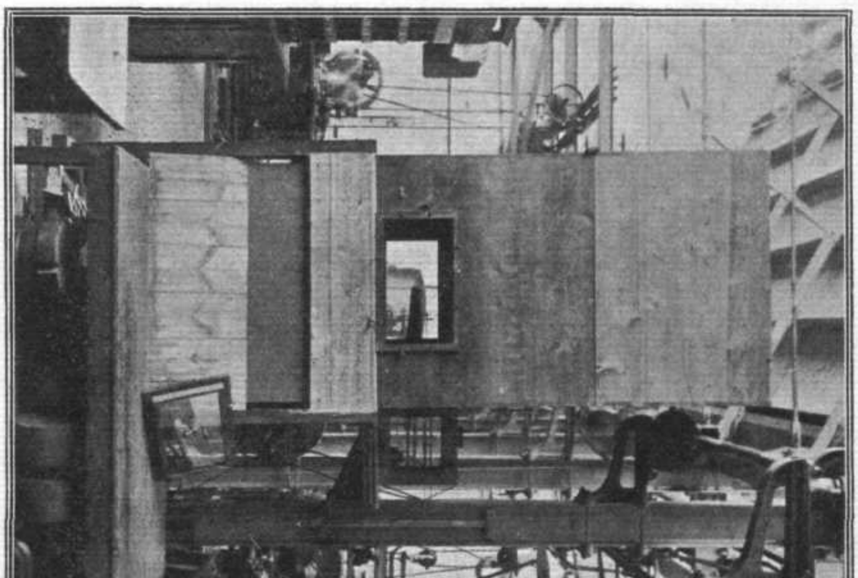
To a large number of people the matter of fact way in which a headquarters was instantly decided upon when the Government had matured its plans for the establishment of an official Committee on Flight may have come somewhat as a surprise, for it is possible that they may have had no occasion to be aware of the existence of the National Physical Laboratory which has its principal home at Bushey House, Teddington. That institution, however, is one of those of which everyone Englishman should be proud, for its purpose is to keep practical science in this country on a level, and, if possible, ahead of other nations. Some people seem very fond of complaining that England is always behind in this, that, or the other branch of knowledge, but they seem to forget that experimental work of the kind on which the great scientific professions build their foundations is of a very expensive character, takes a long time to carry out, and can only be satisfactorily undertaken by trained men who have attained the highest degree of specialisation in that sort of work. To conduct such experimental work out of the resources of an individual firm is essentially to handicap progress in competition with any country in which the State is prepared to assist, so it should not be difficult to realise the fundamental importance to the nation of an institution like that at Bushey House.



Air, like water, is a fluid, and so experiments in water are sometimes a convenient way of observing the conditions which take place in air. The above photograph shows a trough, through which water is circulated in order to investigate its effect on a submerged object.

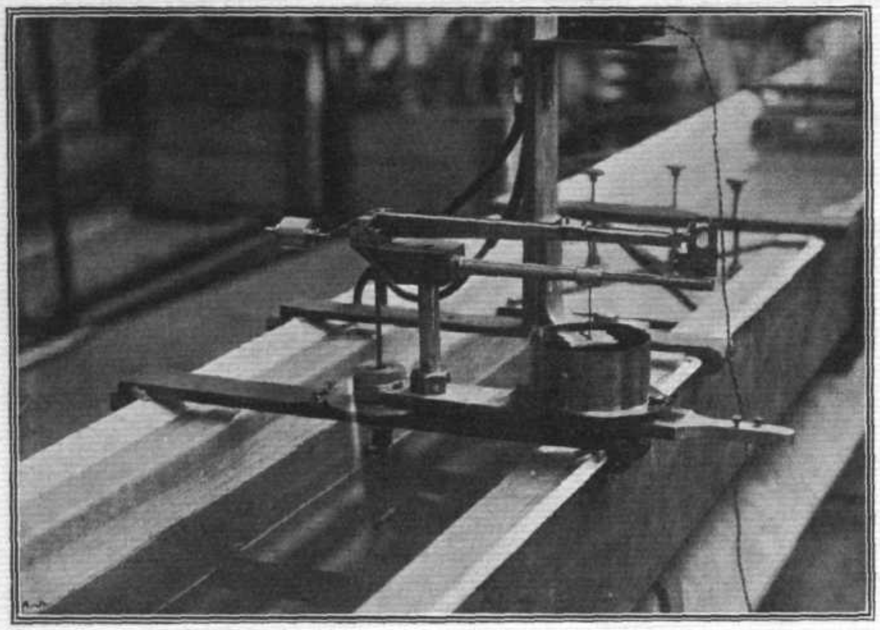
In various departments of engineering and physics, the National Physical Laboratory has been carrying on work of a corresponding character to that which they will now, it is hoped, be enabled to carry out in the furtherance of the science of flight. On the general Board of the Institution are representatives of all the great scientific societies related to the allied industries in the United Kingdom, and much of the work which is carried out there is undertaken at the instigation and expense of the firms who wish to be specially informed on the subjects in question. This work is, of course, supplementary to that which can be conducted out of the State subsidy, which is sufficient to ensure the maintenance of an efficient staff and the carrying out of certain fundamental work. It is, of course, all a question of funds, without which nothing can be done, and a rich man anxious to help his country in a useful way might, we have often thought, do far worse than "endow" a series of experiments on some subject which he has more or less at heart.

In the development of the science of flight it is pleasing to find men of means and leisure coming forward, attracted doubtless in the main by its sporting aspect, to investigate the purely practical side of the subject. They are undertaking an arduous and extremely important task, which is not without its element of danger nor unclouded by the prospect of many failures. But it is indeed a great thing for science when there are to be found men, who might otherwise remain com-



Among the earliest experiments undertaken at the National Physical Laboratory were some made by Dr. T. E. Stanton on air resistance, small models being mounted in the above case, and subjected to the draught of a fan. Some idea of the precautions which have to be taken may be gathered from the fact that it was not found possible to use a plate of more than 5 ins. in diameter in a channel 4 ft. across, lest the effect of the walls should disturb the conditions.

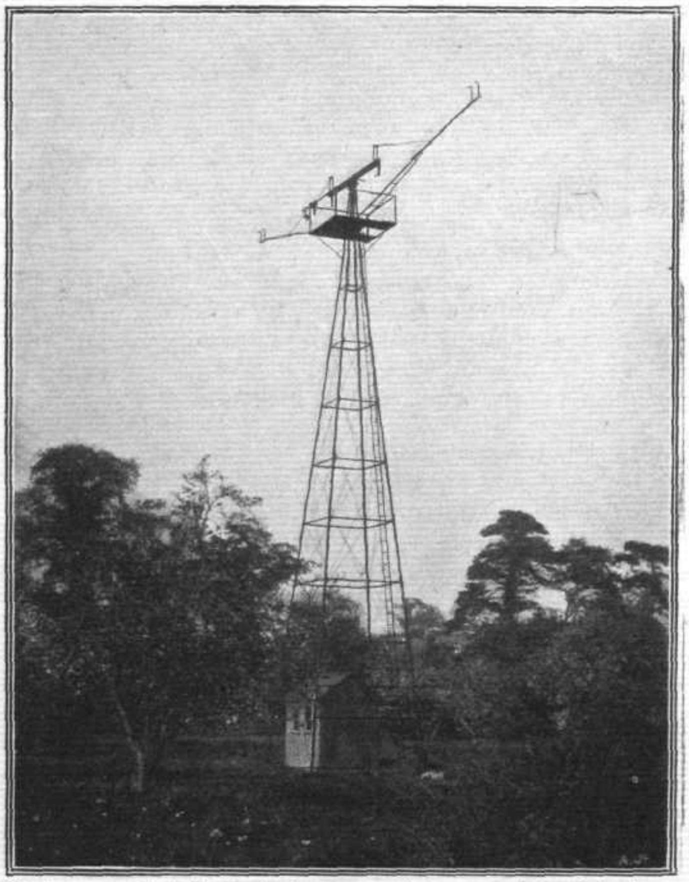
paratively indifferent to the purely scientific aspect of the problem, taking an active part in the movement, in such a manner as to enable practice to go hand in hand with theory. They need have no fear that their good work will not be taken account of by those who will now have charge of the less exhiliarating but equally important experiments comprehended within the scope of the National Physical Laboratory.



In the above photograph the submerged object can be dimly seen under the water, and the apparatus, by means of which the effect of the flow upon it is registered, is mounted above the trough.

It is only natural to ask, what is the National Physical Laboratory going to do? But for the moment no definite answer can be given to this question, for the very simple reason that there has been no time in which to formulate a definite plan of campaign. There are many things that want doing; it is merely a question as to what the Flight Committee decide may be most profitably undertaken first. To those who have studied the science of flight a little, it is a never ceasing wonder that so much should have been accomplished while so many things remain unknown. It is true that men have speculated on the possibilities of flight for centuries, but it is equally true that these speculations have in the main been remarkable rather for the diversity of their conclusions than for the establishment of reliable theories. Practical men have at last been found to build machines which, with the aid of the modern petrol engine, can successfully fly, and by the process of elimination such machines will undoubtedly be improved more and more as time goes on. There comes a time, however, when the direction in which improvement can be undertaken is no longer so easily ascertained from the results of actual flights. The designer comes to need information of a character which can only be satisfactorily obtained from experimental work conducted with the sole purpose of establishing some specific point and no other.

The designer may wish to know, for instance, whether he can possibly improve the curvature of his main surfaces, for having, perhaps, evolved a type which gives reasonable satisfaction he is unwilling to go to the expense of an alteration in a full-size machine without some substantial assurance of success. This is where theory assists the practical man. Theory is not, as some people seem to think, a collection of childish myths, nor is it as others would have us believe, the dogmatic expression of unfounded opinion on the part of some reputed "wise man." Theory, as it is understood at any rate in all practical professions, is the doctrine of the relationship between the fundamental laws of nature so far as they affect the science in question. The fact that bodies fall to the ground if unsupported is so much a matter of common observation that it seems nothing out of the way to the man in the street, but as a fundamental theory in physics it spreads out ramifications so far reaching that it may be said to affect every problem in mechanical science. Yet if man had never been curious about the common properties of falling bodies, he would not have made for himself a tithe of the conveniences by which his life on earth to-day is civilised. So, too, in the development of flight. Two courses are open, either we can sit down and wait for a lucky "discovery" on the part of some practical aviator who has been trying everything he can think of regardless of expense, or we can systematically go to work and make our discoveries to order, in which case they are no longer discoveries but theory; which is to say they are a guide for all time to all men who engage themselves in the conquest of the air. For the convenience of taking a practical example of



Having concluded the indoor experiments on models in a uniform current of air, Dr. Stanton carried out wind-pressure experiments with larger structures mounted on the top of the above tower. The arms stretching out from the platform are 40 ft. apart, and carry an apparatus which enables simultaneous measurements to be made of the wind pressure at each point. It is from these experiments that it has been found that the pressure was never *simultaneously* the same in the two places.

how theory, as established by work to be undertaken at the National Physical Laboratory, can be of assistance to the designer of practical flying machines, we have cited the case of the curvature of supporting surfaces. It is merely an instance of many similar items on which definite information is required. It happens, however, to be one on which nothing is definitely known, and there is, moreover, reason to suppose that its importance is of an extremely fundamental character. Throughout nature, all flying birds have wings of arched section instead of flat planes, and the question is how much should the front edge dip in order to get the best results when the rear edge is at a certain angle of inclination. There is another point of importance, too, about this dipping front edge question. It introduces an hitherto unconsidered factor into the problem of estimating the wind pressure on inclined surfaces. It is this wind pressure which, as our readers know, is the means whereby the flying machine is supported in the air. Yet curiously enough it has so far been found impossible to equate the known laws relating to the air so as to provide a means of accurately estimating results. In other words, theory is incomplete in this direction. But it is possible, and there is reason to think it probable, that a thorough investigation of the arched section may be a means of supplying the missing link.

Then, apart altogether from such details as these, which are attributes of the flying machine itself, there are questions affecting the very air in which they fly. What sort of medium is this air, of which it is said that the conquest has now taken place? Once again it is a case of the curious mind finding out things which are unobserved by the casual. The wind is such an everyday sort of thing, that an inshore man at any rate seldom thinks about it except perchance when it blows his hat off. The aviator of the future, however, will doubtless as a matter of course know more on this subject than is understood by all the experts in the world at the present time, and what is more he will probable regard that knowledge as essential, if not to the safety of his life, at least to the economical expenditure of his power.

Already Dr. Stanton, who is Superintendent of the Engineering Department of the National Physical Laboratory, has carried out most important experiments on wind pressure in order to supply engineers with data which shall enable them to economically construct bridges and buildings in exposed positions strong enough to withstand the force of the gales to which they will be subjected. To the lay mind this may seem simple enough, and not calling for any special investigation, but in reality most important and useful discoveries result from these researches. It is found, for instance, that certain *shapes* are more affected than others of the same area, and it is shown that the full force of the blast is never *simultaneously* operative over a wide field. It follows from the former that certain forms are more advantageous to use than others, and from the latter that the requirements of safety are ensured by something less than the maximum allowances. Such experiments as Dr. Stanton has carried out, however, have in the main been related to the effect of the wind on surfaces exposing a full face to it, or, at any rate, inclined no more than is common in the case of sloping roofs. The experiments of a similar kind conducted in the service of the pioneers of flight would be located obviously at the other end of the scale. The flying machine is based on the effect of wind pressure, but its surfaces move through the air almost edge on, and the whole range of the angles of inclination which may be usefully employed are far removed from those which obtain in other branches of engineering.

Although it has only been possible to indicate in the briefest manner one or two of the subjects which may be said to come within the scope of laboratory experiments, sufficient has, we hope, been said to convey a proper appreciation of the enormous importance to the future of flight, of the work which is about to begin at our National Physical Laboratory when the necessary apparatus for conducting the experiments has been installed.

TEACHING THE YOUNG IDEA—ANOTHER METHOD.

DELIVERING lectures is one way of teaching the young idea, and it is, as we have had occasion to point out, a method of spreading the movement which is to be highly commended. There is, however, another system which, if it possesses greater limitations, is perhaps still more fascinating to the young idea itself. And that is a scheme in vogue at the Royal United Services College at Windsor.

Among the buildings now possessed by that institution is a laboratory which has been stocked with experimental apparatus presented by that very generous patron of the science of flight, Mr. Patrick Y. Alexander, who himself uses the laboratory for much of his experimental work. Unlike most experimenters, however, Mr. Alexander does not in the least object to interruptions, and it is a privilege possessed by the boys at the college that they may go into the laboratory whenever they like during their leisure hours and ask questions about anything they see. Needless to say, they ask a good many questions, and it may be supposed that they are in a fair way to pick up a considerable amount of useful information. They are allowed to build model flyers, and among other possessions are a pair of gliders with which, by the aid of a tow-rope, the boys have already been enabled to make a certain limited, but nevertheless direct, acquaintanceship with the air. Altogether, through Mr. Alexander's generous latitude to these youths, much good seed is being sown, which in later years should bear good fruit from the more matured mind.

FLIGHT IN PARLIAMENT.

IN the House of Commons on Monday, Mr. Asquith stated that although he could not at present name the precise sum which would be placed this year at the disposal of the Special Aeronautic Committee, the War Office, and the Admiralty, for practical work, the amount would be considerable.

Mr. Haldane informed Mr. Fell that it was believed Germany had constructed seven dirigibles, and five more were under construction. Although it was difficult to get precise information, it appeared that in 1907 £25,000 had been allotted, and in 1908 £107,500. No information was forthcoming in answer to a further question as to whether Parliament would be asked for a similar sum to that demanded by the German Government, and whether at least one big dirigible would be constructed, although the Secretary for War promised to give full information at the proper time.

FLIGHT ACCORDING TO LANCHESTER.

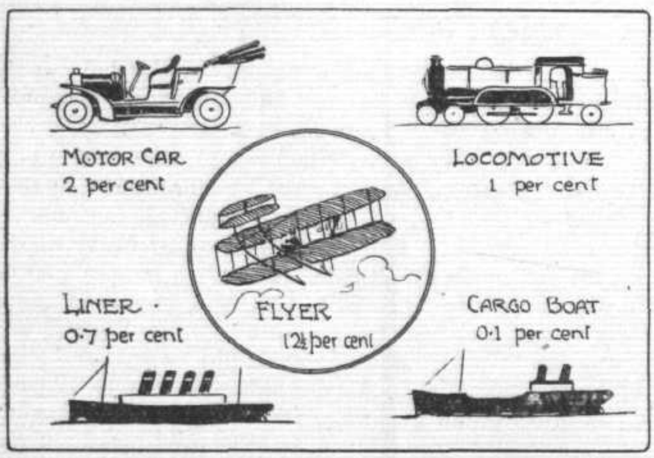
MR. F. W. LANCHESTER, WHOSE NAME IS SO WELL KNOWN IN CONNECTION WITH MOTOR CARS, HAS BEEN INVESTIGATING THE PROBLEM OF FLIGHT FOR THE PAST FIFTEEN YEARS. AT AN EARLY PERIOD HE SUCCESSFULLY CHECKED HIS THEORETICAL DEDUCTIONS BY MODEL EXPERIMENTS, AND MIGHT WELL HAVE BEEN THE FIRST TO HAVE MADE A SUCCESSFUL MAN-CARRYING FLYER, BUT THAT MR. DUGALD CLERK, ANOTHER LEADING AUTOMOBILE AUTHORITY, PERSUADED HIM NOT TO TURN HIS ATTENTION FROM HIS IMMEDIATE ENGINEERING PURSUITS.

SELDOM, perhaps never in its history, has the magnificent lecture hall of the Institution of Civil Engineers held an audience which so frequently demonstrated an intensely appreciative interest as when* Mr. F. W. Lanchester discussed the aerodynamics of flight before the members of the Institution of Automobile Engineers. Speaking with inimitable lucidity and precision on problems which were often abstruse, Mr. Lanchester succeeded in an hour and a half in conveying to his hearers a concrete grasp of a subject for the full treatment of which he has found two large volumes no more than sufficient space in print.

In our own treatment of the subject, therefore, it has been necessary to adopt a certain latitude of scope in order to make up somewhat for the obvious deficiencies of a printed account of a lecture which was frequently punctuated with special references to lantern slides, diagrams, and model experiments. It is a common occurrence that the most lucid addresses are the least convincing in type, and indeed any literal report of a lecture, as distinct from a "Paper," is often apt through this very cause to be well-nigh unintelligible. In the following article we have endeavoured by every means in our power to do justice to the most able disquisition which has yet been delivered on the theory of flight.

The Resistance of a Flyer.

In approaching the problem of flight, even from a general and comparatively superficial point of view, a most obvious query which might well be asked at once by anyone taking an intelligent interest in such matters, is as to how a flying machine might be expected to



The resistance that has to be overcome in moving a load from one place to another can be expressed as a percentage of the load itself. It is least in a cargo boat and most in a flying machine, as the above figures show.

compare with other forms of locomotion in the matter of resistance to transit. On land it is common to express the value of this resistance as a percentage of the total weight of the vehicle itself, and the co-efficient thus obtained depends, as all engineers know, on the nature of the tyres and road. With pneumatics it is about 2 per cent., with solid rubber tyres 3 per cent., with iron tyres on wood pavement, say 2·2 per cent., and on macadam roads, say 3·3 per cent. Railways under ordinary conditions offer a resistance which is only 1 per cent. of the load, while ships like the "Lucania" have a co-efficient traction of 0·7 per cent., which in an 8-knot cargo boat may be reduced to 0·1 per cent. Here, therefore, at the outset are some well-known values, which have been established by numerous experiments, and must necessarily serve as a basis for comparison in the case of new methods; hence the reasonableness of an immediate inquiry into the resistance of an aeroplane.

If an investigation is made of the Voisin and Wright flyers (Table I), which are pre-eminently the only two really successful types at the present day, it will be found that the values for the co-efficient of traction are not less than 13·5 per cent. and 12·5 per cent. respectively, figures which are both in the nature of four times the value obtained from quite indifferent systems of traction on land. Arising out of this possibly unexpected result is the question as to whether such high resistance is essential to dynamic flight, which leads, of course, to a close investigation of the factors of which the resistance in question is a function.

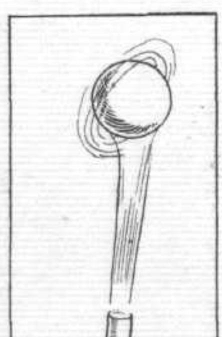
TABLE I.—*Table of Power Expended.*

	Velocity. Ft.-Secs.	Lbs. Sustained per h.p. Indicated h.p.	Thrust h.p.	Resistance. Per cent.
A model	17	—	220	14·7
Wright	58	50	76	12·5
Voisin	66	34	62	13·5

Langley's Error.

It would be only proper under such circumstances to turn in the first place to the records of such a prominent man in the annals of flight as Professor Langley, and here certain statements of obvious significance are at once apparent. Langley has stated, in so many words, that the horse-power required diminishes as the velocity of flight increases; also that the skin-friction of a flying machine is negligible.

In Professor Langley's opinion, therefore, it is very evident that high resistance in flight is not essential. It will be shown later that the first part of his conclusion, viz., that the horse-power diminishes as the velocity increases, has its basis in fact; but it may be mentioned at once that the assumption as to the negligibility of skin-friction in air is entirely invalid, and because of this fact Prof. Langley's view is fundamentally at fault.



The rotation of a light sphere supported on an inclined jet of air demonstrates the existence of skin-friction.

Proof of Skin-Friction.

That skin-friction is not negligible may be shown by a very simple experiment, in which a light hollow sphere, such as, for instance, a little celluloid ball, is caused to be

* On April 28th.

supported upon a stream of air projected upwards from a jet.

It can be shown mathematically that if skin-friction be neglected all the forces which at any instant can possibly operate upon the sphere have each and all of them their vectors directed to its centre, when it is obviously impossible for the body under such circumstances to rotate. Now skin-friction in respect to a sphere would be represented by a tangential force, so that if skin-friction exists in the system described, the irrotational state will no longer result, since it requires but a tangential component to establish rotation about any arbitrary axis. The sphere is placed in the jet,* which is inclined now to the left, and now to the right, and the sphere, it will be observed, rotates in one direction and then in the other. Thus, by a simple little experiment, can skin-friction be demonstrated, and it only remains to put a practical value upon its co-efficient.

Values of the Skin-Friction Co-Efficient (ξ).

Although it is so easy to demonstrate that skin-friction exists, it is less simple, not to say a matter of great difficulty, to accurately establish definite figures for its co-efficient (ξ), that is to say, to express it as the decimal fraction of the resistance which would be encountered by the same plane moving normally (*i.e.*, face-on) instead of "edge-on." By means of delicate tests, however, the following figures have been obtained :—

1. For smooth planes on a few square inches area at low velocities of about 10 ft. per sec., $\xi = \cdot 02$ to $\cdot 025$.
2. For larger planes of from $\frac{1}{2}$ to $1\frac{1}{2}$ sq. ft. in area, moving about 20 to 30 ft. per sec., $\xi = \cdot 009$ to $\cdot 015$.

From these figures it will be observed that skin-friction, so far from being negligible, becomes a dominating factor in flight, where it accounts for much of the resistance, and maintains its high order by neutralising the effect of high speed on power. The precise relationship between the co-efficient and the velocity is an investigation of an extremely interesting character, but for the moment it is unnecessary to do more than make a statement to the effect that for all practical purposes the resistance due to skin-friction may be regarded as proportional to V^2.

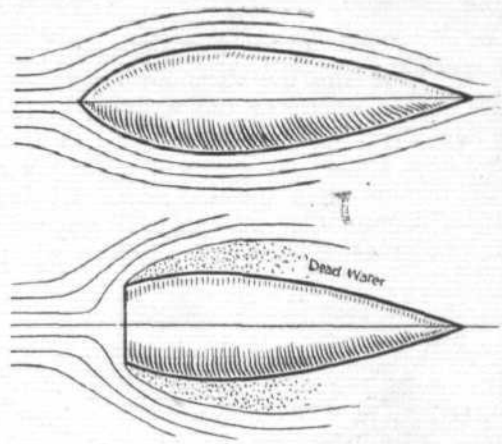
How to Reduce the Co-Efficient.

In investigating the problem of skin-friction, theory leads to the conclusion that its nature must be that of micro-turbulance between the surface of the body in flight and the contacting fluid. It is not alone a matter of viscosity, for if it were it would not vary as V^2,† as it has been found to do in practice. In order to reduce the resistance which it creates, the only way is to use surfaces which are as smooth as possible.

Head Resistance.

Allied to skin-friction is that of direct resistance due to head resistance, which results in creating eddies by setting up surfaces of discontinuity in the wake. The only known way of avoiding this loss of power is to use smooth contours of ichthyoid or fish-like form, so that the resultant stream-line flow of the fluid shall keep it in touch with the surface of the body. There is no mathematical equation for a stream-line shape of body, but nature in the form of fishes, and man in his experiments with submarines and projectiles, has evolved suitable shapes for specified practical purposes.

In parenthesis, it is worth mentioning that if real fluids possessed the properties of the Newtonian medium of theory, which by hypothesis has no viscosity, any shape of body, however rugged, would be of stream-line form and would meet with no resistance under this heading in flight.

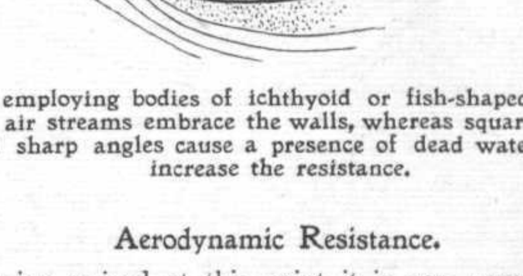


By employing bodies of ichthyoid or fish-shaped form the air streams embrace the walls, whereas square ends and sharp angles cause a presence of dead water and increase the resistance.

Aerodynamic Resistance.

Having arrived at this point it is now necessary to revert to that other aspect of the problem which has to do with the statement that the horse-power diminishes with the speed of flight. It is not, as has already been stated, a complete solution in itself, owing to the fact that it ignores skin-friction.

There is, in addition to the skin-friction and that other direct resistance already discussed, a resistance (y) of aerodynamic kind, which results from the supporting of the machine in flight. In this case it can be proved that neglecting skin-friction and edge effect, which have already been taken into account separately, the resistance in the line of flight varies as the angle of inclination (β)



The aerodynamic resistance encountered by a plane in flight is proportional to the load carried, W, multiplied by the angle of inclination, β.

of the plane multiplied by the weight (W) sustained.* The weight supported is sensibly equal to the normal reaction (P_β) upon the plane, which in turn can be shown to be proportional to the angle of the plane (for small angles) and to V^2. It follows, therefore, that, if the weight is constant, the angle of inclination is itself inversely proportional to the square of the velocity, and, as the resistance is proportional to the angle, then the resistance consequently bears the same inverse, V^2, relationship to the speed, whence also, of course, the power required for a given weight sustained on a given area varies inversely as the velocity of flight.

* Mr. Lanchester performed this experiment at a lecture in Birmingham, but was unable to repeat it in London owing to the absence of necessary apparatus.

† *See* Lanchester's Aerodynamics, Chapter II.

* *See* Lanchester's Aerodynamics, p. 226.

Put mathematically, these statements may be expressed as follows:—

Aerodynamic resistance (alone) $y \propto W\beta$

Normal reaction on inclined plane $P_\beta = W$

" " " " $\propto V^2\beta$

$\therefore W \propto V^2\beta$

whence $\beta \propto W/V^2$

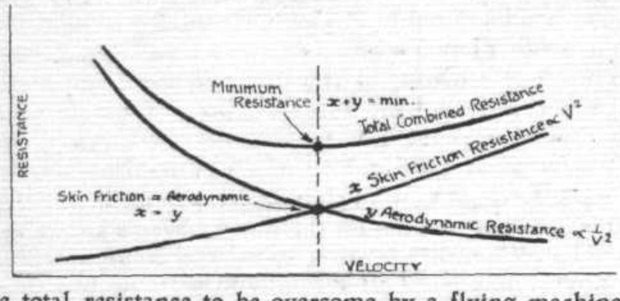
or when W is constant $\beta \propto 1/V^2$ (i)

but $y \propto \beta$ $\therefore y \propto 1/V^2$ (ii)

and work done per sec. $= yV$ $\therefore$ h.p. $\propto 1/V$ (iii)

Minimum Resistance.

The fact that the aerodynamic resistance, y, varies inversely as the square of the velocity, while the skin-friction and edge effect, x, vary directly, as V^2 shows that there will be a certain condition of minimum resistance where the two curves in question intersect. It is easy to show by a diagram that this point is reached when the two resistances, aerodynamic and direct respectively, are

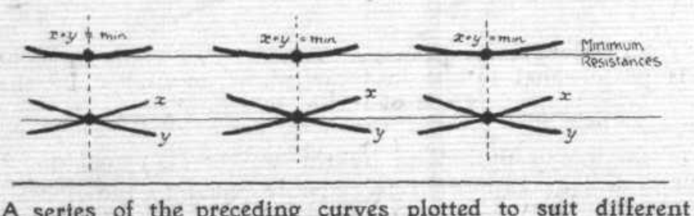


The total resistance to be overcome by a flying machine is represented by the sum of the aerodynamic and skin-friction resistances, and has a minimum value when its two components are equal to one another.

exactly equal to one another. This is an important and particularly interesting conclusion, inasmuch as it establishes the balance which must exist in aeroplanes between these two factors in order that the resistance to transit should have a minimum value, and that in consequence the machine shall be able to fly furthest on a given expenditure of fuel; *in other words, it requires the least possible horse-power to sustain flight when $x = y$.*

Effect of Area.

It will have been observed that, in the foregoing, a fixed and invariable area has been assumed in addition to a known load. It may, of course, be supposed that the load is always a rigidly determined quantity, for a flying machine is presumably designed with a view to carrying some specific number of persons. It by no means follows, however, that the area is likewise fixed in advance; indeed, it is a factor which the designer is at



A series of the preceding curves plotted to suit different areas, shows that the minimum resistance remains unaltered.

liberty to vary at will, and it remains to be seen with what advantageous results he may alter this dimension.

It may be assumed that in any case it is desired to produce the minimum resistance to flight, the present problem being merely to see whether one area or another will give a lower total minimum. It is obvious that if the area be reduced, the velocity must be increased to support the same load, and *vice versa*. Consequently for any given area there will be a corresponding pair of resistance-velocity curves, from a series of which will be obtained the desired sequence of minimum points representing the lowest possible total resistance for the range of specified conditions. If such curves be plotted it will be found that the minimum points all lie on a horizontal straight line, that is to say, they are all equal in value, which means no less than the total minimum resistance $(x + y)$ to flight is absolutely independent of velocity.

Weight Determines Resistance.

Assuming, therefore, that a flying machine is perfectly designed in respect to resistance, that is to say, its aerodynamic and direct resistances are equal to one another (*i.e.*, $x = y$), then it will be impossible to improve upon that machine by endeavouring to carry the load at any other speed. For if smaller surfaces are used that it may be carried faster, or conversely supposing that larger surfaces are used that it may be carried slower, in every case the best possible balance that can be effected will have the same numerical value.

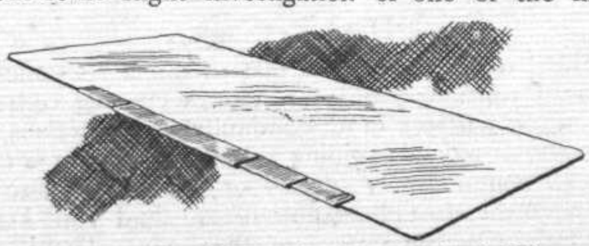
The particularly interesting point about the solution to this problem is that it shows the resistance to be a function of the weight, and thereby enables the designer to estimate the resistance in advance directly the weight to be carried is known, assuming, of course, that he is in possession of the necessary constant required to complete the simple equation. Practical evidence in support of the mathematical proof of the independence of resistance in respect to velocity is forthcoming from data given in the table of power expended (Table I), where it will be noticed that a small model plane, the Wright flyer and the Voisin flyer, all have resistances which are approximately equal to one another.

Body Resistance Varies as V^2.

In dealing with the subject of resistances, it is necessary to discriminate between those which are part and parcel of the aeroplanes proper and those which are introduced because of the presence of a bulky body. The body of an aeroplane would be of more or less fixed dimensions in accordance with the load to be carried, while the supporting surfaces, it has been shown, may be varied to suit the requirements. The resistance encountered by the body is that due to skin-friction and edge effect, and must consequently be included in the general calculations as an addition to the quantities which vary directly as V^2. The effect of the body is essentially to raise the co-efficient of traction.

Value of Model Experiments.

While many interesting deductions have been arrived at by the foregoing arguments, the story is hardly complete without some slight investigation of one of the most



A model plane made of mica loaded with lead foil on the front edge can be used for making experiments.

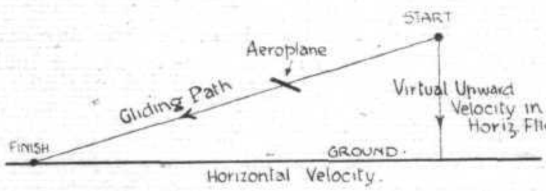
fascinating sides of the subject, fascinating because it can be so beautifully demonstrated by means of models. Launching little model planes into the air affords a most instructive series of experiments, besides being one of the

best possible methods of fixing one's ideas on a somewhat abstruse problem. If a little model plane be launched it will glide to earth at an angle which it is not difficult to measure. As an example, one such a device launched freely in still air demonstrated a uniform velocity of 17 ft. per sec. down an inclined path having a slope of 1 in 6·8. The body as a whole was, therefore, falling down through space at the rate of 2·5 ft. per sec., and from this simple experiment a straightforward deduction can be made of the power required to sustain flight under similar conditions.

Taking no account of the actual weight of the model under consideration, but bearing in mind only the conditions which it represents, that is to say, a rate of fall of 2·5 ft. per second as a glider, it will be evident that such a system will be sustained in horizontal flight if power is applied to counteract the falling tendency, as already defined. If 220 lbs. weight of such models were employed as a coherent system, then the power required to impart to it a virtual upward velocity of 2·5 ft. per second would be exactly 1 h.p., from which the statement can be made that in such a system the weight sustained per h.p. would be 220 lbs.

Flying is Uphill Work.

This is a fundamental line of argument, and one very important to be properly understood. It will be observed, for instance, that horizontal flight is the equivalent of raising a corresponding weight vertically upwards at some slower speed represented by a percentage of the flight



Launched in free air such a model will glide to earth down a path of constant slope; hence horizontal flight is like going uphill on terra firma.

velocity itself. By analogy horizontal flight is comparable with motoring perpetually uphill, which is an important and most useful simile to bear in mind, as nothing could better emphasise the nature of the main item on which power is expended in flight.

The gradient of comparison is given by the natural gliding angle of the system, determined by experiment in the manner already described. In the case of the model which has just been discussed, the slope of fall was 1 in 6·8, consequently the virtual gradient of ascent equivalent to horizontal flight will also be 1 in 6·8, that is to say, the power required to sustain the model in horizontal flight will be equivalent to the additional power which the engine of a motor car of the same weight would be called upon to develop in order to climb a hill of 1 in 6·8 at the same speed.

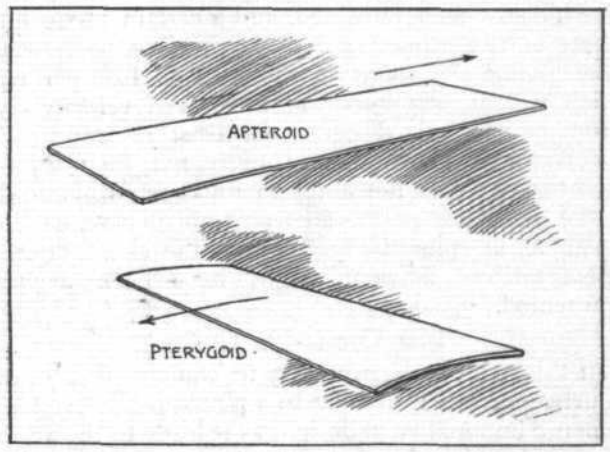
Resistance from the Gliding Angle.

A slope of 1 in 6·8 is, expressed in equivalent figures, a slope of 14·7 in 100, or in other words it is a slope of 14·7 per cent., and in consequence the resistance which the slope itself imposes is 14·7 per cent. of the weight. This figure, derived as it is from quite a tiny model, brings back the argument to the starting point, where, at the end of the second paragraph, entitled "The Resistance of a Flyer," it was stated that the values for the co-efficient of traction in the Voisin and Wright flyers are 13·5 per cent. and 12 per cent. respectively, figures which are in sufficiently close agreement with the above-mentioned 14·7 per cent. to afford very startling experimental evidence of the validity of the statement that the resistance is independent of velocity, and can therefore be pre-determined from the weight. It is assumed that the body resistance is relatively small in comparison with the total resistance.

This conclusion is, as will have been gathered, the gist of the intermediate arguments, the most important of which go to show that the only condition necessary to maintain its validity is that the flying machine shall always be designed for least resistance by having its aerodynamic and direct resistances equal to one another.

Pterygoid and Apteroid.

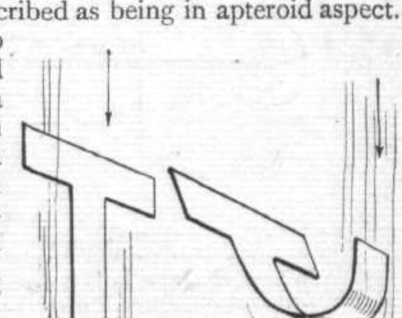
Throughout the preceding considerations it has been assumed that the aeroplane, whatever its size, is constant in respect to its "aspect ratio."



The experiment of the sketch below is a proof that the pterygoid or broadside-on arrangement of the planes is more efficient than the apteroid or end-on method.

The aspect ratio is the proportion between the lateral and longitudinal dimensions of plane considered in the line of flight. When the ratio is greater than unity, that is to say, when the spread is the major axis of the plane, the plane is said to be in pterygoid aspect, while when flying "end-on" it is described as being in apteroid aspect.

All evidence goes to show that the pterygoid aspect results in a greater pressure reaction for a given area, and a simple proof of this can be obtained by experimentally dropping a sheet of paper cut in the form of a "T." When the model is dropped thus, T, with the stem downmost, it falls like a stone to the ground, showing that the pterygoid cross-piece at the top acts like a feather of an arrow. Conversely, when let fall thus, ⊥, with the cross-piece downmost, it will invariably curl round in mid-air, so as to reverse the position, thus showing that the pressure reaction on the transverse member is greater than that on the apteroid stem; in other words, that the "broadside-on" machine is more efficient than the "end-on" machine.



A T-shaped plane dropped stem first falls straight, but dropped head first reverses its position.

If the ratio of the transverse to the fore and aft dimension of a pterygoid aeroplane is increased, the weight sustained for a given area is increased also. It follows, therefore, that it is necessary among other things to know the value of this ratio, n, before it is possible to either analyse or design an aeroplane for a given load.

Constancy of the Skin-Friction Co-efficient.

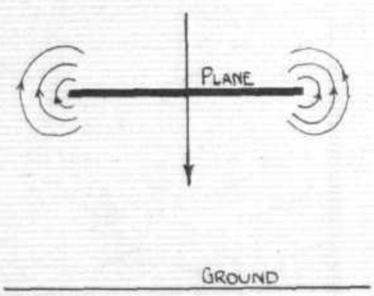
It has further been assumed in previous arguments that the co-efficient of skin-friction is constant. This assumption is justified by the investigations of Allen,* the conditions of such constancy being that the product of some linear dimension, defining the area, into the velocity shall remain unchanged. And in the case of an aeroplane, it has just been shown in a previous paragraph relating to the effect of area that this condition applies, hence the co-efficient of skin-friction depends on the weight alone.

Taking a certain range of skin-friction values, such as have already been indicated, and a certain range for the values of the aspect ratio, it is possible to draw up a table giving the value of the load in lbs. per sq. ft. which will be supported at any given velocity by an aeroplane which is designed for least resistance. This last factor is essential, and must not be overlooked. Such values would not apply to a machine which did not fit the minimum point of its resistance curve, as already explained, in spite of the fact that the skin-friction and aspect ratio co-efficient might have been accurately represented.

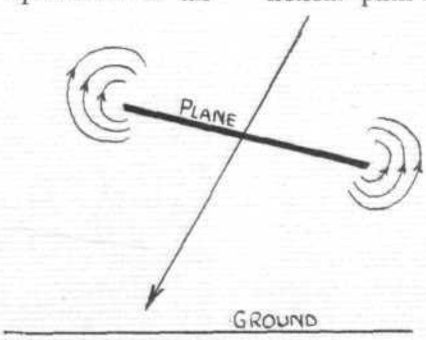
The Cyclic-Up Current.

At this point it is necessary to branch off from direct sequence in order to refer to a phenomenon which is of immense importance to design, as it leads to the adoption of a cambered surface instead of a flat plane. And here it may be convenient to adopt the use of the term "aerofoil" to denote a surface of indeterminate contour as distinct from a plane which implies, in fact specifies, flatness.

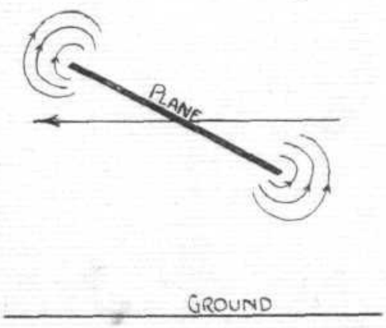
When a plane falls normally through a vertical path, there is set up around the edges an up-current of air which flows in to make good the space previously occupied by the falling body. If the downward fall is compounded with a horizontal velocity, so that the net result is a sloping glide, it will not change this essential up-current or cyclic disturbance. The imposing of a horizontal component in this way is equivalent, it will be evident, to replacing the ground line by another in some other position according to the slope of fall. Or, if the horizontal component is sufficient, it will give horizontal flight still without having changed the cyclic disturbance.



When a plane falls normally, *i.e.*, face on, a cyclic disturbance takes place round its edges.



If the same plane falls along an oblique path the cyclic disturbance will still prevail.

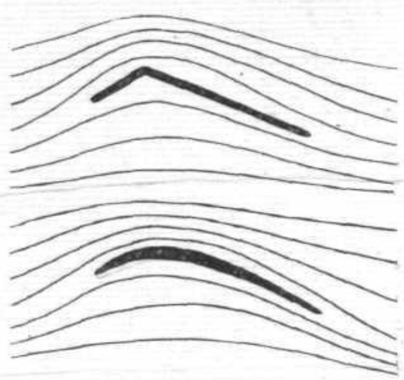


If the oblique fall is changed for horizontal flight, there is still the cyclic up-current preceding the front edge of the plane.

The effect of the horizontal component of motion is to cause a plane to be continually running into its own cyclic up-current, and in consequence it is like flying in a wind with an upward trend.

The Arched Section.

Such being the case, a simple oblique plane is obviously inadequate, for it is incapable of taking advantage of the upward flow, which everywhere precedes it in flight. In order to adapt the plane to the conditions it produces, it is obviously necessary to turn down or dip the front edge, from which it at once follows that the front and rear edges would be connected by a curved surface in order to avoid sharp corners; hence the cambered section that is always used for aerofoils in practice.



In order to take advantage of the cyclic up-current the aeroplane needs a dipping front edge, which evolves into the arched section of practice in order to avoid sharp angles.

Nature, too, affords a proof of the correctness of this principle, for the dipping front edge is a characteristic feature of the bird's wing. Moreover, the well-known inaccuracy of the ordinary formula connecting pressure and velocity by means of air density in the inclined plane are eliminated in the cambered aerofoil when the angle of entry is reckoned with the angle of trail.

Proof of Cyclic Motion in a Propeller.

There is a great deal that is of immense interest in the study of cyclic disturbance, and one of the objects that may be investigated to advantage is the propeller. A propeller is in effect a series of aerofoils flying in a helical path: each blade is itself a complete aerofoil, having one extremity terminating at the boss. Hydrodynamic theory demands that cyclic motion can only exist in a "doubly-connected" region—a term which it is not easy to exactly define in simple language—and from this it follows that if, as is assumed from the foregoing theory, cyclic motion exists round the blades, it will be demonstrated in the wake. Photographs which have been taken of a propeller in water, have demonstrated that such is the case, the cyclic motion manifesting in the form of vortex cords paying off from the blade tips and from the propeller-boss. It will be noticed that the latter phenomenon is manifested at the

* See Lanchester's Aerodynamics, Chapter II.

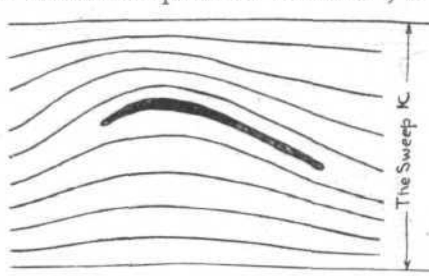
boss of the propeller and not at the roots of the blade as might have been expected.

Lifting Power and Sweep.

Reverting now to the preceding paragraph, the accuracy introduced into pressure-velocity equation by taking account of the value of the dipping front edge in the calculation, establishes the practical utility of the Newtonian method applied to the calculation of the lift of aerofoils.

Air, by the Newtonian method, is regarded in principle as consisting of entirely disconnected molecules, which by being infinitely small, constitute an inviscid fluid. On this hypothesis the pressure-velocity equation becomes $P = mv$ in absolute units where m is the mass per second of the air particles which have been given a change in velocity $= v$. This change in velocity is determined by the angles of entry and trail, and as both are assumed to be small, their equivalent sum in circular measure may be considered as representing v, in terms of the flight velocity itself.

The mass dealt with by the aerofoil is less easily arrived at owing to the undefined sphere of its action; it affects a strata of air above and below its surface, the total depth of which—termed the sweep—may be shown to be a function of the area. Experiment suggests that the co-efficient of sweep (κ) is in the order of unity; that is to say, the depth of the strata may, for practical purposes, be taken as about equal to the fore and aft dimension of the aerofoil, from which the mass per second can be calculated accordingly. The experimental value of the sweep, as stated above, is demonstrated from the fact that a pair of superposed aerofoils (a biplane), do not appreciably interfere with one another, that is say, each exerts its full lifting value, when placed a distance apart, equal to the fore and aft dimension.



The lifting power of an aerofoil depends upon its sweep, *i.e.*, the depth of the strata of air which it disturbs.

The Tables.

Sufficient has been said to show that there is very considerable interconnection between the factors that influence aerofoil design, and pursuing the study of this side of the question to its natural conclusion results in establishing a series of constants to connect the opposite sides of the different equations.

All these values are related to the aspect ratio (n), as is shown in the accompanying table (Table II), which table, in addition, contains a series of angles of inclination (β, trail) calculated for minimum resistance, that is to say, for a minimum gliding angle (γ). The conditions of minimum resistance ($x = y$) have already been discussed, and it is of the utmost importance to bear in mind that the whole basis of the table, and, in fact, the various theories associated with it, depend upon this hypothesis.

Two of the constants, those relating to sweep (κ), and to the ratio (ϵ) between the angles of entry (α) and trail (β), are unknown, so values which are plausible in the light of theory and experimental evidence have been given.

TABLE II.

Table of Constants and Angles.

(Calculated for least resistance.)

					$\xi = ·03$		$\xi = ·025$		$\xi = ·02$		$\xi = ·015$		$\xi = ·01$	
n	C	c	κ	ϵ	β	γ	β	γ	β	γ	β	γ	β	γ
					°	1 in	°	1 in	°	1 in	°	1 in	°	1 in
3	·685	2·16	1	·48	13·2	8·3	12	9·2	10·8	10·2	9·3	12	7·6	14·5
4	·70	2·27	1·03	·54	13·75	9	12·5	10	11·2	11·1	9·7	13	7·9	15·7
5	·71	2·38	1·064	·59	14·14	10	12·9	10·8	11·6	12	10	14	8·1	16·8
6	·72	2·48	1·10	·62	14·4	10·4	13·2	11·5	11·8	12·8	10·2	14·7	8·3	17·9
7	·725	2·55	1·12	·65	14·8	11	13·5	12·2	12·15	13·5	10·5	15·9	8·5	19·1
8	·73	2·62	1·14	·68	15·0	12	14	12·8	12·5	14·4	10·8	16·8	8·8	20·5
10	·74	2·73	1·175	·72	16·0	12·8	14·7	14	13·0	15·8	11·3	17·9	9·2	22
12	·75	2·80	1·195	·75	16·8	13·7	15·3	15	13·7	16·8	11·8	19	9·7	23·9

n = Aspect ratio.
C = Normal pressure constant; $P_{90} = C\rho V^2$ where P_{90} = normal pressure; ρ = density of air; V = velocity ft./secs.
c = Oblique pressure constant; $\rho_\beta / P_{90} = c\beta$ where β is the angle of inclination.
κ = Sweep constant; sweep $= \kappa A$ where A = area. Values given are merely plausible.
ϵ = Angle ratio $= \alpha/\beta$ where α = angle of entry, and β = angle of trail. Values given are merely plausible.
β = Angle of trail for γ = minimum.
γ = Gliding angle.
ξ = Co-efficient of friction (by experiment).

TABLE III.—*Load Table.*

(Pterygoid Aerofoil.)

	Speed.	Velocity.	Load (pounds) per Square Foot for Least Resistance.							
			Values of "n":—							
			3	4	5	6	7	8	10	12
	m.p.h.	ft. per sec.								
$\xi = ·030$	3·42	5	·020	·023	·025	·027	·029	·031	·034	·037
	6·85	10	·082	·092	·101	·108	·115	·124	·136	·148
	10·3	15	·186	·207	·228	·245	·260	·280	·307	·333
	1·37	20	·331	·367	·405	·435	·462	·497	·546	·593
	17·1	25	·516	·574	·633	·680	·721	·777	·852	·926
	20·5	30	·743	·827	·911	·978	1·04	1·12	1·23	1·33
	24	35	1·01	1·12	1·24	1·33	1·41	1·52	1·67	1·82
	27·4	40	1·32	1·47	1·62	1·74	1·84	1·99	2·18	2·37
	34·2	50	2·06	2·30	2·53	2·71	2·88	3·11	3·41	3·70
	41	60	2·97	3·31	3·65	3·91	4·15	4·47	4·91	5·33
	48	70	4·05	4·50	4·96	5·32	5·64	6·09	6·70	7·25
	54·7	80	5·29	5·89	6·48	6·95	7·39	7·95	8·73	9·48
$\xi = ·020$	3·42	5	·017	·018	·020	·022	·023	·025	·028	·030
	6·85	10	·068	·075	·082	·089	·094	·101	·111	·121
	10·3	15	·152	·169	·186	·200	·213	·228	·250	·272
	1·37	20	·270	·300	·330	·355	·379	·405	·445	·484
	17·1	25	·390	·433	·475	·511	·545	·582	·641	·697
	20·5	30	·610	·676	·743	·800	·852	·911	1·00	1·09
	24	35	·830	·920	1·01	1·08	1·16	1·24	1·36	1·48
	27·4	40	1·08	1·20	1·32	1·42	1·51	1·62	1·78	1·94
	34·2	50	1·69	1·88	2·06	2·22	2·37	2·53	2·78	3·03
	41	60	2·44	2·70	2·97	3·20	3·40	3·64	4·01	4·36
	48	70	3·32	3·68	4·05	4·35	4·64	4·96	5·46	5·93
	54·7	80	4·33	4·81	5·30	5·70	6·07	6·47	7·13	7·75
$\xi = ·010$	3·42	5	·012	·013	·014	·015	·016	·018	·019	·021
	6·85	10	·047	·053	·058	·063	·066	·071	·079	·085
	10·3	15	·107	·119	·131	·142	·150	·161	·177	·192
	1·37	20	·190	·211	·234	·253	·267	·287	·315	·341
	17·1	25	·298	·331	·366	·396	·418	·450	·495	·535
	20·5	30	·427	·475	·526	·570	·601	·645	·710	·769
	24	35	·582	·647	·717	·777	·820	·880	·967	1·04
	27·4	40	·760	·845	·935	1·01	1·07	1·15	1·26	1·36
	34·2	50	1·18	1·32	1·46	1·58	1·67	1·79	1·97	2·13
	41	60	1·71	1·90	2·10	2·28	2·40	2·58	2·84	3·07
	48	70	2·32	2·58	2·86	3·10	3·27	3·51	3·86	4·18
	54·7	80	3·04	3·38	3·73	4·05	4·27	4·59	5·05	5·45

For each value of the angle of trail (β) as defined by the table there is a corresponding definite relationship between the area (A), speed (V), and load (W), carrying capacity of the aerofoil. This relationship serves to establish the load table (Table III) in which can be found the weight per square foot supported at different velocities between 5 and 80 ft. per sec. It is interesting to apply this table—prepared long before any machines had flown—to the Farman flyer of the present day. The velocity of that machine is about 70 ft. per sec., and the aspect ratio 5, which with a skin-friction co-efficient of ·01 would give about 3 lbs. per sq. ft. lift, a figure which is sufficiently close to the real value demonstrated by experiments.

The model of Table I has frequently been referred to in the text: its thrust horse-power is deducted from the component of gravity in gliding. It approached earth at 2·5 ft. per sec., and as 1 h.p. (550 ft.-lbs.-secs.) could maintain that upward velocity in ($550 \div 2·5 = 220$) lbs., therefore the model in horizontal flight, which is equivalent to an upward velocity of 2·5 ft.-secs., requires power at the rate of 1 h.p. per 220 lbs. weight. The flight velocity resulting from this is, by experiment, 17 ft. per sec., and as when gliding the fall is 2·5 ft. per sec., it follows that the natural gliding angle of the model is $\frac{2·5}{17} = \frac{1}{6·8} =$ 14·8 per cent., which, as has already been explained, constitutes a measure of the total resistance.

In the case of the Wright and Voisin machines, the flight velocities, and the weights and the engine powers, are known experimentally. The thrust h.p. developed by the propellers is deduced from the motor h.p. by allowing for the losses in transmission, and, in consequence, the load supported per thrust h.p. is greater than the equivalent for engine h.p. This value of lift has a corresponding value for rate of fall, for just as with the model a lift of 220 lbs. per. h.p. represented a fall of $550 \div 220 = 2·5$ ft. per sec., so in the case of the Wright flyer does a lift of 76 lbs. per h.p. represent a natural gliding fall of $550 \div 76 = 7·23$ ft. per sec., which, compounded with a flight velocity of 58 ft. per sec., indicates a natural gliding angle of 1 in 8, or $12\frac{1}{2}$ per cent., which once again is a measure of the flight resistance.

BRITISH AEROPLANE AND AIRSHIP.

Mr. Cody Flies a Mile.

ON the 14th inst. Mr. S. F. Cody, on the discarded Army aeroplane, succeeded in making a really good flight, and set up a new record for Great Britain by flying for a mile, reaching an altitude of 30 feet. On the previous day three short flights were made with a view to seeing that one or two improvements which had been made by Mr. Cody worked satisfactorily, and in view of the results Mr. Cody determined on making a great effort on the following morning. About ten o'clock the motor was started, and after a few short runs over the ground Mr. Cody started from one end of Laffan's Plain, and flew right to the other end and beyond to Danger Hill, where he alighted without mishap. News of the success quickly spread, and reached the Prince and Princess of Wales, who were attending the manœuvres at Aldershot. In the afternoon the Prince asked Mr. Cody if he would make another flight, and he once more took to the air. Unfortunately, however, in making a turn to avoid some troops, after flying for about 200 yards, the aeroplane was caught by a sudden gust of wind and driven against an embankment, damaging some of the rear framework. The damage done was not very serious, and the Prince expressed to Mr. Cody his pleasure at having seen a British aeroplane that could fly.

Royal Visitors Inspect "Dirigible II."

ON Friday week the Prince and Princess of Wales paid a visit to the balloon factory, and inspected the new model army dirigible, and also witnessed it in flight. The airship, which has now been christened "Baby," was taken out on to Cove Common, and after Col. Capper had explained its design and working, the dirigible was sent up with Capt. King, R.E., and Mr. McQuade in charge. She made a wide circle, returning practically to the starting point, a speed of about fifteen miles an hour being attained. On Tuesday the King also inspected the airship during his visit to Aldershot.

Mr. Cody in full flight on his aeroplane last week at Laffan's Plain, when he made a record flight of a mile.

AERO CLUB OF THE UNITED KINGDOM.

OFFICIAL NOTICES TO MEMBERS.

Fixtures for 1909.

May 22	...	International Balloon Race, Hurlingham Club.
June 23	...	Balloon Race, Hurlingham Club.
July 10	...	Balloon Race, Hurlingham Club.
July 17	...	Balloon Race, Hurlingham Club.
August 28	...	Gordon-Bennett Aviation Cup, Rheims.
October 10	...	Gordon-Bennett Balloon Race, Zurich.

Committee Meeting.

A meeting of the Committee was held on Tuesday, the 18th inst., at 166, Piccadilly, W., when there were present: Mr. Roger W. Wallace, K.C., in the chair, Mr. Griffith Brewer, Mr. Ernest C. Bucknall, Mr. Martin Dale, Mr. John Dunville, Mr. F. K. McClean, Mr. J. T. C. Moore-Brabazon, Mr. C. F. Pollock, Hon. C. S. Rolls, Mr. Stanley Spooner, H. E. Perrin (Secretary).

New Members.—The following new Members were elected:—

William St. Vincent Bucknall.	Miss Anna McClean.
Capt. Bagot Chester.	James L. Travers.
Lieut. J. T. Cull, R.N.	Reginald J. Wallis-Jones.
Mrs. John Dunville.	Mrs. Cora Chase Whitney.
Capt. Francis Hausburg.	John V. Worthington.
Lieut. B. V. Layard, R.N.	

International Balloon Race, Hurlingham.

The International Balloon Race will take place at Hurlingham Club, Fulham, S.W., to-day, Saturday, May 22nd, 1909, at 3.30 p.m.

Members of the Aero Club will be admitted to the Hurlingham Club free on presentation of their Aero Club Membership Cards.

Members of the Aero Club can obtain special tickets for the admission of their friends, who are not members of the Aero Club, to Hurlingham, from the Secretary of the Aero Club, price 10*s*. each.

The following is the order of starting:—

1.	Capt. A. H. W. Grubb, D.S.O., R.E.	Venus	... England
2.	Dr. F. Linke ...	... Ziegler	... Frankfort, Germany
3.	C. F. Pollock ...	... Valkyrie	... England
4.	Hon. C. S. Rolls	... Mercury	... ,,
5.	Griffith Brewer ...	... Vivienne	... ,,
6.	F. K. McClean ...	... Corona	... ,,
7.	Direktor Neumann	... Tillie	... Frankfort, Germany
8.	Major Sir A. Bannerman, Bart., R.E.	Satellite	... England
9.	Ernest C. Bucknall	... Enchantress	,,
10.	Philip Gardner ...	... Kismet	... ,,
11.	H. Demoor ...	... Belgica	... Belgium
12.	John Dunville ...	... Banshee	... England
13.	Dr. Hütz ...	... Moenus	... Frankfort, Germany
14.	V. Ker-Seymer ...	... La Mascotte	England

The new balloon acquired by the Aero Club will follow the race, in charge of Major Baden-Powell.

Flying Ground at Shellbeach.

Railway Arrangements.

The South-Eastern and Chatham Railway Co. have agreed to allow members of the Aero Club and Aero Club League visiting the flying ground at Shellbeach reduced fares, as under:

1st Class Return	2nd Class Return	3rd Class Return
8*s*.	6*s*. 6*d*.	5*s*.

These tickets will be available for one month from date of issue.

Members desiring to avail themselves of these reduced fares are required to produce vouchers at the booking offices. Vouchers can be obtained from the Secretary of the Aero Club.

Trains leave Victoria, Holborn, or St. Paul's.

For the convenience of members, the best train is the 9.45 a.m. from Victoria, arriving at Queenborough 10.55. At Queenborough change to the Sheppey Light Railway for Leysdown (Shellbeach), which is ¾-mile from the flying ground.

Members of the Aero Club and Aero Club League visiting Shellbeach are requested to have with them their membership cards, as strict instructions have been given to admit only members to the flying ground.

Gordon-Bennett Aviation Cup.

The Competition for the Gordon-Bennett Aviation Cup will take place at Rheims on August 29th next, and the Aero Club have already sent in three entries.

The Committee of the Aero Club will select three competitors to represent this club, and intending candidates are requested to notify the Secretary on or before the 31st May of their willingness to compete if chosen. Applications must be accompanied by a cheque for £20, the entry fee, which amount will be returned should the candidate not be selected. Up to the present four members have entered.

The full rules governing the contest can be obtained from the Secretary of the Aero Club of the United Kingdom.

Frankfort Exhibition.

It is proposed to organise an English day for balloon competitions in connection with the Frankfort Exhibition, and the date suggested is between September 3rd and 7th next.

The Exhibition authorities will provide free gas, and two or three balloons will be placed at the disposal of the English competitors. Three cups of the total value of £100 will be offered as prizes. Members of the Aero Club wishing to take part should communicate with the Secretary.

Travel Exhibition.

Members of the Aero Club and the Aero Club League wishing to exhibit model flying machines in connection with the Aero Club exhibit at the Travel Exhibition in July next are requested to notify the Secretary of the Aero Club as soon as possible. *Space and stands will be provided free of charge.*

HAROLD E. PERRIN, Secretary.

The Aero Club of the United Kingdom,
166, Piccadilly, W.

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Lecture at Regent Street Polytechnic.

ON Tuesday next, at 8 p.m., Capt. W. G. Windham will deliver a lecture on Flight, illustrated by cinematograph and other lantern illustrations, at the Regent Street Polytechnic. The chair will be taken by Major Baden-Powell, and tickets can be obtained from the Secretary of the Polytechnic.

Gordon-Bennett Aviation Cup.

THE closing date for entries for the French Eliminating Trials for the Gordon-Bennett Aviation Cup has now been postponed to July 22nd, the same day as that on which entries for the other events of the Champagne week close.

NEWS OF THE WEEK.

Santos Dumont at Issy.

ALTHOUGH Santos Dumont has not made any advance on his performance of April 8th, when he flew for 2½ kiloms., he has not been idle. On Saturday last he had the "Demoiselle" out, and in the morning made three good flights, one of them being for more than a kilom. A slight mishap occurred when landing after the third flight, the tail striking the earth rather suddenly and getting a little damaged. Repairs, however, were soon executed, and in the evening the little flyer was out again. Upon this occasion, after making a flight of about 200 yards, Santos Dumont attempted to turn, when the wind rather upset his calculations, with the result that one wing came into somewhat rude contact with the earth. In consequence three fractured tubes resulted, and as soon as these are repaired M. Dumont will resume his trials.

Henry Farman at Chalons.

BY way of keeping *au fait* with the art of riding the wind, Mr. Henry Farman has been making one or two flights on his No. 1 machine. At dusk on the 11th inst., despite a strong wind which was blowing, he flew for about 8 kilometres. On the following morning he made a flight of about three minutes in duration. M. Jean Gobron, one of Mr. Farman's pupils, has, in the meantime, made several flights of from 500 to 600 metres in length. On Saturday Mr. Farman made several flights of about 800 metres in length, carrying a passenger weighing over 14 stone.

Comte Lambert at Cannes.

COMTE LAMBERT is now installed at the Napoule racecourse, near Cannes. On the afternoon of the 17th instant, he started flying by covering 400 metres in a straight line. He then circled round the flying ground, and finished up by describing two figure "8's" over the racecourse, one being completed in 2 min. 3 secs., and one in 1 min. 25 secs.

Mr. Lathom at Chalons.

ON Wednesday last, Mr. Hubert Lathom made an attempt on his Antoinette monoplane to win one of the Aero Club's new prizes for a flight of 500 metres by a pupil.

M. Delagrange Training at Juvisy.

M. DELAGRANGE is training at Juvisy in preparation for the competition for the Legatinerie prize at the opening of Port Aviation. He is using his old machine, and on Tuesday made a flight at a height of about 20 metres, circling three times round the flying ground.

A Prize for French Military Officers.

VISCOMTE HENRY DE KERSAINT, a member of the Committee of the Société d'Encouragement à l'Aviation, has founded a prize of 5,000 francs, which may be extended to 10,000 francs, to be competed for at Port Aviation by officers of the French Army on active service.

Aviation in Denmark.

Two flyers are shortly to be seen in the neighbourhood of Copenhagen—Dr. Folmer Hansen, who has been taking lessons from Mr. Henry Farman, having purchased a Farman biplane with which he hopes to, presently, start flying at the Klampenborg racecourse, about 15 kiloms. from the Danish capital. The second machine will be a Wright flyer which M. Delagrange will take to Denmark at the end of the present month or the beginning of June, and with which he will make flights at Aarhus-Jutlands, where an International Exhibition is to be held this year, and also at the Amac military parade ground.

Wright Flyers in Germany.

FROM Berlin it is announced that a company with a capital of 500,000 marks (about £25,000) has been formed by the General Electricity Company for the purchase and exploitation of the Wright patents in Germany. It is further stated that the company is paying the Wright Brothers 200,000 marks for the patents in Germany, Norway, Sweden, Luxemburg, Denmark, and Turkey, to include any improvements which may be made in the future. The purchase price also covers the delivery of one machine, which is to be flown at Berlin by one of the Brothers Wright. Besides the G.E. Co., Messrs. Krupp (Essen), Ludwig, Loewe and Co., and Elbruck and Co., are bracketed with the undertaking.

THE GOUPY AEROPLANE.—The biplane, of somewhat unusual design, with which M. Goupy is now experimenting at Buc. It will be seen that the upper planes are a little in advance of the lower one, and that the aviator sits behind the front planes. The biplane, which has been built by M. Bleriot, has a lifting surface of 26 sq. metres, the main planes having a spread of 6 metres, and being 1·6 metres across, while the length of the machine is 7 metres. A 29-h.p. R.E.P. motor drives the four-bladed tractor-screw, and the complete machine weighs 290 kilogs.

Flying in Spain.

A COMMITTEE which is being subsidised by the Minister of War is at present at work in Madrid endeavouring to organise a series of aeronautic competitions and fêtes to take place in October next. Should the Wright Brothers accept the Committee's invitation to take part, they are to receive an indemnity of 25,000 pesetas (£1,000), and a similar sum for the construction of a flyer.

Juvisy Opening Postponed.

IT has been decided to postpone the opening of the Juvisy Aerodrome for a few days, it being now proposed to have the formal ceremony either on May 30th or the first Sunday in June. Probably the second date will be the one chosen, as the first clashes with the unveiling of the monument at Toury in commemoration of M. Bleriot's cross-country flight.

A kite competition is to be held to-morrow (Sunday)

The Salomons Cup, presented by Sir David Salomons, Bart., to the Aero Club for competition under the conditions published in "Flight" of May 1st, page 246. This beautiful work of art is a reproduction by Messrs. Hunt and Roskell, Ltd., of New Bond Street, from the original work by Paul Lamerie, which was sold at Christie's for £500.

at "Port Aviation" (as it is now called), and the nine entries include three aigloplans, two of which are 2·2 metres by 3·6 metres, entered by MM. Saulean and Ronan, and the other, 1·5 by 2·6 metres, by M. Peuvol; a multi-cellular kite, 1·6 by 2 metres, by M. Berranger; a Hargreave cellular kite, by M. Echalie; one by H. Vinour; and three hexagonal cellular kites, 2 by 1·7 metres, by M. Frantzen.

Anjou Meeting Abandoned.

HAVING come to the conclusion that aviators will be too busily occupied preparing for the Rheims Meeting at the end of August, the Aero Club de l'Ouest, on the advice of M. René Gasnier, have after all decided to abandon the meeting they were organising for July 11th to 18th.

Vichy Aero Meeting.

IT has been decided to hold the flight competitions at Vichy from June 12th to 20th, and among the prizes to be won is the Grand Prix of Vichy of 10,000 francs. The plans for the aerodrome which the Société Ariel propose to construct at a cost of 27,000 francs have been approved by the Ae.C. Vichy, and it is expected that some of the hangars will be ready for the first of the new Wright aeroplanes by the end of this month.

Prix de la Tenue de l'Air.

THIS is the title given to one of the prize schemes which will swallow up 9,000 francs of the Government subsidy to the Aero Club of France. There will be four prizes, of 5,000, 2,500, 1,000, and 500 francs respectively, which will be awarded to the four aviators who, from the time of entry to the end of the year, spend the most time in the air while taking part in properly controlled competitions or events. The entry list was opened on the 15th inst. by the Aero Club of France, the entry fee being 100 francs. In order to count for the award, ascents need not necessarily be made in France, but the events must be under proper official control, and the aviator must, within eight days after his performance, send full particulars, together with proofs, to the Commission Aérienne Mixte.

250-Metre Prizes for Pupils.

AT its last meeting, the Commission Aerienne Mixte formally approved of the award of the three prizes for first flights of 250 metres by pupils to MM. Comte Lambert, M. P. Tissandier, and M. Demanest.

Engines and Fittings for Models.

READERS of FLIGHT who have been enquiring of us for engines and small fittings suitable for the equipment of models used in flight experiments will be pleased to hear that these details are being made a speciality of by Messrs. Eyquems Patents, who inform us that they are already engaged in the stocking of a large quantity of such parts.

The Antoinette Tractor-Screws.

THE Antoinette monoplane, as readers of FLIGHT are fully aware, is fitted with a tractor-screw in front of the machine like most of the other monoplanes at the present day. The view of this flyer, which appeared on page 281 of last week's issue of FLIGHT, was, of course, therefore a view from in front and not, as, by a slip, it was stated, a view from behind.

German Government and Zeppelins.

THE trouble between the Zeppelin Company and the Government appears to be reaching an acute stage, and as the German War Office refuse to purchase more than two Zeppelins, the company have been obliged to seek a fresh outlet for their resources. So arrangements are being made to utilise the Zeppelins which are under construction for passenger work. With a view, no doubt, to winning the aid of the Parliament, Count Zeppelin has invited the Members of the Reichstag to inspect the

airship during the Whitsuntide holidays, and he has also offered to take a certain number for a little trip. Apparently, the fact that the Balloon Department of the German Army is controlled by officers more interested in the semi-rigid type of airship is responsible for the trouble.

Speaking at Stuttgart recently, the managing director of the Company building the Zeppelin airships said that not only did the German War Office refuse to order any more Zeppelins but they were constructing sheds which were not large enough to admit these airships. The shed, for instance, which is to be erected in Gotha will only be 283 ft. long, and this decision has evoked a strong protest from the Zeppelin Co.

Zeppelin "Liners."

DISAPPOINTED with the Government, the Zeppelin Co. have approached the authorities of various cities with a view to their subsidising an aerial passenger service, and the idea seems to have been pretty well received. Interested persons at Cologne are, it is stated, willing to invest £25,000, and a similar sum will be forthcoming from Dusseldorf. At present, it is intended to commence with a line from Lucerne to Dusseldorf, on which two airships will be employed, while a third one will be employed to encircle the Rigi. It is estimated that each trip would take about four hours, and if the three ships made 600 trips in a year the cost would be £85,000, which would be met by a subsidy from the Army and the fares of passengers.

Mr. Wellman Preparing.

MR. WELLMAN is now in Paris preparing for his next attempt to reach the North Pole in his dirigible "America," having arrived from New York on Monday. He hopes to go to Spitzbergen next month, and to make a dash for the Pole during August. He estimates that the De Dietrich engine on his airship can drive it at 18 knots, and with 6,000 lbs. of petrol on board, the vessel should have a radius of action of 2,000 miles, and the journey of 700 miles between Spitzbergen and the Pole should be accomplished, as well as the return trip, without it being necessary to have recourse to the sledges.

Week-End Ballooning.

ON Saturday afternoon last Mr. John Dunville ascended from Hurlingham in his balloon "Banshee," which has a capacity of 80,000 cubic feet. A full complement of seven passengers were in the car, including the Hon. Mrs. Assheton-Harbord, Mr. C. F. Pollock, and Mr. F. McClean. When the balloon ascended, Mr. Ernest Bucknall's "Enchantress," which had started from Wandsworth Gas Works, was passing directly overhead, and as she was making very slow progress it was decided to keep to a lower current, which carried the balloon westward. A little later in the afternoon "Continental No. 1," which was a feature at the Aero Exhibition, made her maiden ascent from Hurlingham. The balloon, which is of 50,295 cubic feet capacity, was piloted by the Hon. C. S. Rolls, and he had as passengers Mr. Charles Jarrott and Mr. Paul Brodtmann. A fine journey was made, passing over Richmond, Windsor, and Reading, and eventually a descent was made on Beedon Common, near Newbury. The highest altitude reached was a little over 5,000 feet. Although the "Continental" started an hour and a quarter after the "Banshee," she travelled a good deal faster, and came in sight of the latter near Virginia Water, when the passengers were able to communicate with each other by signals. Eventually Mr. Dunville brought his balloon down at Buckhold, about three miles from Pangbourne.

Transatlantic Ballooning.

AFTER the arrangements which are being made to cross the Atlantic by dirigible, it seems to be a retrograde step to suggest a Transatlantic voyage in a mere balloon. Mr. Clayton, an American meteorologist, however, has an idea that two miles up there is a "planetary air current" which would take a balloon from New York to Europe in three or four days. Mr. Clayton is getting a balloon of 200,000 cu. ft. capacity, and intends to make the trip as soon as he is proficient in the art of handling his balloon, for which purpose he proposes to make a series of trips between California and New York.

Auctioneers and Flight.

IT is proverbial that auctioneers are generally up-to-date, and leave few stones unturned in their endeavours to make a favourable impression concerning any property they may be offering for sale. On Saturday the old disused fort known as Steyne Wood Battery was sold, together with 12 acres of freehold land, by order of the Secretary of War; and one of the recommendations put forward by the auctioneer was that the property was suitable as an exercise ground for aeroplanes. Eventually Sir John Thornycroft secured the ground, but whether he intends to utilise it for flying experiments was not disclosed.

The Institute of Flight.

THE Hon. Sec. (Mr. P. L. Senecal) of this body writes to inform us that the Executive Committee was re-elected for the year at a meeting held on Wednesday of last week. The annual subscription was then fixed at 10*s.* 6*d.* for Members and 5*s.* for Associates residing outside a 40-mile radius of London; and it was decided to hold a general meeting early in June if possible.

PRIZES IN AMERICA.

THROUGH the courtesy of our American contemporary *Aeronautics*, we are able to give a full list of the prizes which have been offered in America, and which are still open to be won. The anonymous gift of 20,000 dollars, which was announced at a banquet on January 31st, has not yet, we understand, materialised. The list of American prizes is as follows:—

Donor.	Value.	Conditions.	Control.
	dollars.		
Aeronautics ...	200	50 dollars each to the first four aviators to fly 500 metres in a straight line	
C. F. Bishop ...	1,000	250 dollars each to the first four aviators to cover a kilom. during 1909	Ae.C.A.
New York World	10,000	Flight to Albany, 150 miles, during week of Hudson-Fulton celebration. Either dirigibles or aeroplanes	Ae.C.A.
F. S. Lahm ...	250	Flight of 1 mile out of Canton, O.	
W. R. Timken ...	100,000	Offered to an inventor, *for his invention*, if he can fly 100 miles and return	
Lee S. Burridge...	25	For gliding flights and models	
O. Chanute ...	25	" "	
W. R. Kimball ...	25	" "	
Aeronautic Society	10,000	Not yet settled, but will be divided into four prizes of 2,500 dollars each, and put up for competition during the season	Aeronautic Society.

PRESENT STATUS OF MILITARY AERONAUTICS.

By GEORGE O. SQUIER, Ph.D., Major, Signal Corps, U.S. Army.

(*Concluded from page 285.*)

IV. AERIAL LOCOMOTION IN WARFARE.

WHATEVER may be the influence of aerial navigation upon the art of war, the fact which must be considered at present is, that each of the principal military powers is displaying feverish activity in developing this auxiliary as an adjunct to the military establishment.

If each of the great Powers of the world would agree that aerial warfare should not be carried on, the subject would be of no great interest to this country as far as our military policy is concerned, but until such an agreement is made this country is forced to an immediate and serious consideration of this subject in order to be prepared for any eventuality.

The identical reasoning which has led to the adoption of a policy of providing for increasing our navy year by year to maintain our relative supremacy on the sea, is immediately applicable to the military control of the air. If the policy in respect to the navy is admitted, there is no escape from the deduction that we should proceed in the development of ships of the air on a scale commensurate with the position of the nation.

The question as to whether or not the Powers will ultimately permit the use of aerial ships in war is not at present the practical one, because in case such use is authorised it will be too late adequately to equip ourselves after war has been declared.

Action of the Hague Peace Conference.

The following is the declaration signed by the delegates of the United States to the Second International Peace Conference held at The Hague, June 15th to October 19th, 1907, prohibiting the discharge of projectiles and explosives from balloons, ratified March 10th, 1908.

Declaration :—

The contracting Powers agree to prohibit, for a period extending to the close of the Third Peace Conference, the discharge of projectiles and explosives from balloons or by other new methods of a similar nature.

The delegates of the United States signed this declaration. The countries which did not sign the declaration forbidding the launching of projectiles and explosives from balloons were : Germany, Austria-Hungary, China, Denmark, Ecuador, Spain, France, Great Britain, Guatemala, Italy, Japan, Mexico, Montenegro, Nicaragua, Paraguay, Roumania, Russia, Servia, Sweden, Switzerland, Turkey, Venezuela.

It appears that the United States is the only first-class Power who signed this agreement, and an analysis of the text of the agreement itself shows that no serious attempt was made to settle the question finally.

For instance, while the war balloon may not discharge projectiles or explosives from above, yet no reciprocal provision is made preventing such war balloon from being fired upon from the earth below, yet the law of self-defence evidently obtains.

Furthermore, naval experts will tell you that they fear no enemy quite as much as a submarine mine, whose location is unknown and which gives no warning when it is approached. Our own experience shows that the battleship " Maine " could be completely destroyed in time of peace without anyone detecting the preparations for its accomplishment.

If, then, a nation can submerge a mine for the destruction of ships from underneath the water, why can it not drop an aerial mine upon a ship from above? And if it should be allowed to drop an aerial mine upon an enemy's fortified ship at sea, it certainly should be allowed to drop such an aerial mine upon a fortified place on land.

Influence on the Military Art.

The military art up to the present time has been practically conducted in a plane where the armies concerned have been limited in their movements in time and place by the physical character of the terrane. A large army, for instance, cannot move faster than about 12 miles a day by marching, and the use of railroads as applied to the art of war was first recognised in the Franco-Prussian war. By their use, the mobilisation of the great Prussian army, and its accurate assembling in the theatre of operations within ten days, contributed an initial advantage not before possible.

The very essence of strategy is surprise, and there never were better opportunities than at present for a constructive General to achieve great victories. But these victories, to be really great, must be founded upon some new development or use of power not heretofore known in war. They must also tend to produce results with the minimum loss of human life. In other words, the sentiment of the world demands that the military art shall always aim to capture, not destroy.

It may be said, that the consummation of military art is found in manœuvring the enemy into untenable situations, thereby forcing a decisive result with a minimum loss of life and treasure.

As to the technical use of dirigible balloons and aeroplanes in warfare we have nothing but theory at present to guide us. It would appear, however, in the case of dirigible balloons that two different classes of such ships should be developed.

First.—A comparatively small dirigible type with a capacity of from 50 000 to 100,000 cub. ft., to be used principally for scouting purposes and to a limited extent for carrying explosives for demolitions or for incendiary purposes, such as destroying bridges and supply depôts close to the mobile army or coast defence fortress. In reconnoitring dirigibles of this class, in order to be safe during daytime they will have to manœuvre at an altitude of about a mile, but experiments show that telephotographic apparatus will operate from this height to give much detail.

At night, such dirigibles may descend to within a few hundred feet of the ground with safety, and thus obtain much valuable information. Equipped with wireless telegraph or telephone apparatus, military data could be obtained and transmitted without undue risk. Due to the small carrying capacity of such sizes, the radius of action would probably be limited at present to about 200 miles.

Second.—This type of dirigible may be developed for burden-bearing purposes. It has been pointed out above that the larger the airship the greater the speed it may be given, and the greater its radius of action. There is no reason to doubt that airships of capacity from 500,000 to 1,000,000 cub. ft. may be ultimately developed to attain speeds of 50 to 75 m.p.h. With a capacity for such speed, the aerial craft becomes a powerful practical engine of war which may be used in all ordinary weather. By keeping high in the air in day-time, and descending at night, they may launch high explosives, producing great damage. Being able to pass over armies and proceed at great speeds, their objectives would not usually be the enemy's armies, but their efforts would be directed against his base of supplies ; to destroy his dry-docks, arsenals, ammunition depôts, principal railway centres, storehouses, and indeed the enemy's navy itself.

It is thought that there will be little difficulty in launching explosives with accuracy, provided good maps and plans are available. Due to the small costs of such ships as compared with naval vessels, the risk of loss would be readily taken.

The element of time has always been a controlling factor in warfare. It is often a military necessity to conduct a reconnaissance in force to develop the enemy's dispositions. This requires at times a detachment of several thousand men from the main army for a considerable period of time to accomplish this end. With efficient military airships, these results may be attained with a very few men in a small fraction of the time heretofore required.

Delimination of Frontiers.—The realisation of aerial navigation for military purposes brings forward new questions regarding the limitation of frontiers. As long as military operations are confined to the surface of the earth, it has been the custom to protect the geographical limits of a country by ample preparations in time of peace, such as a line of fortresses properly garrisoned. At the outbreak of war these boundaries represent real and definite limits to military operations. Excursions into the enemy's territory usually require the backing of a strong military force. Under the new conditions, however, these geographic boundaries no longer offer the same definite limits to military movements. With a third dimension added to the theatre of operations, it will be possible to pass over this boundary on rapid raids for obtaining information, accomplishing demolitions, &c., returning to safe harbours in a minimum time. We may, therefore, regard the advent of military ships of the air as, in a measure, obliterating present national frontiers in conducting military operations.

One of the military objectives in warfare is usually the enemy's capital city, his ministers, and his chief executive. This objective has heretofore been protected by large armies of soldiers, who in themselves are not so important to the result. In order to attain the objective, it has been frequently necessary to subdue large numbers of soldiers needlessly.

With the advent of efficient ships of the air, however, small parties may pass over these protective armies on expeditions aimed at the seat of Government itself, where reside the body of particular individuals most responsible, so that the ultimate result will be to deter a rash entrance into war for personal ends ; since now for the first time responsible individuals of state may be in immediate and personal danger after the declaration of war, which heretofore has not been usually the case.

Interior Harbours.

In the development of these larger types of dirigible balloons the main difficulty will be in providing suitable harbours or places of safety, for replenishing supplies, and in seeking shelter in times of stress. As long as the dirigible balloon remains in the air it may be regarded as tolerably safe, both in itself and as a conveyance for observers. If its engines are disabled, it is at least a free balloon, and may be operated as such.

When brought in contact with the ground, however, it is in considerable danger from high winds. The momentum of such an enormous airship is great, and the comparatively fragile structure of the craft makes it an easy prey to the pounding which it is likely to receive when landing. Just as marine ships must seek a sheltered harbour or put to the open sea in times of storm, so in case of ships of the air, it is much more necessary either to brave the storm in the open or to seek some sheltered harbour on land.

Fortunately, in this case, certain suitable harbours for very large ships may be provided at small expense, by using narrow and deep valleys and ravines, surrounded by forests or other protection, or prepared railway cuts, &c., where the airship may descend and be reasonably safe from the winds above. These harbours should, of course, be known to the pilot, and carefully plotted on the maps beforehand. The compass bearing of each harbour from prominent points on land must be known and plotted, to assist as far as possible in navigating the airship in thick weather; and such harbours may be indicated to the pilot at night by vertical searchlight beams, or by suitable rockets, &c.

The aeroplane, as has been pointed out, is likely to prove a flying machine of comparatively low tonnage and high speed. It is not likely to become a burden bearing ship, at least in single units, but will be extremely useful for reconnoitring purposes, for dispatching important orders and instructions at high speed, for reaching inaccessible points, or for carrying individuals of high rank and command to points where their personality is needed.

One of the bloodiest contests the world has ever seen, was the Japanese attack on "203 Metre Hill," yet the sole object of this great slaughter was for the purpose of placing two or three men at its summit to direct the fire of the Japanese siege guns upon the Russian fleet in the harbourt at Port Arthur.

If the United States had possessed in 1898 a single dirigible balloon, even of the size of the one now at Fort Meyer, Virginia, which cost less than $10,000, the American army and navy would not have long remained in doubt of the presence of Cervera's fleet in Santiago Harbour.

The world is undoubtedly growing more humane year by year. We have arrived at a conception of the principle of an efficient army and navy, not to provoke war but to preserve peace, and it is believed that, following this principle, the perfection of ships of the air for military purposes will materially contribute, on the whole, to make war less likely in the future than in the past.

APPENDIX No. 1.

SIGNAL CORPS SPECIFICATION, No. 486.

Advertisement and Specification for a Heavier-than-Air Flying Machine.

To the Public:

Sealed proposals, in duplicate, will be received at this office until 12 o'clock noon on February 1st, 1908, on behalf of the Board of Ordnance and Fortification for furnishing the Signal Corps with a heavier-than-air flying machine. All proposals received will be turned over to the Board of Ordnance and Fortification at its first meeting after February 1st for its official action.

Persons wishing to submit proposals under this specification can obtain the necessary forms and envelopes by application to the Chief Signal Officer, United States Army, War Department, Washington, D.C. The United States reserves the right to reject any and all proposals.

Unless the bidders are also the manufacturers of the flying machine they must state the name and place of the maker.

Preliminary.—This specification covers the construction of a flying machine supported entirely by the dynamic reaction of the atmosphere, and having no gas-bag.

Acceptance.—The flying machine will be accepted only after a successful trial flight, during which it will comply with all requirements of this specification. No payments on account will be made until after the trial flight and acceptance.

Inspection.—The Government reserves the right to inspect any and all processes of manufacture.

General Requirements.

The general dimensions of the flying machine will be determined by the manufacturer, subject to the following conditions:—

1. Bidders must submit with their proposals the following—

(*a*) Drawings to scale, showing the general dimensions and shape of the flying machine which they propose to build under this specification.

(*b*) Statement of the speed for which it is designed.

(*c*) Statement of the total surface area of the supporting planes.

(*d*) Statement of the total weight.

(*e*) Description of the engine which will be used for motive power.

(*f*) The material of which the frame, planes, and propellers will be constructed. Plans received will not be shown to other bidders.

2. It is desirable that the flying machine should be designed so that it may be quickly and easily assembled and taken apart and packed for transportation in army wagons. It should be capable of being assembled and put in operating condition in about one hour.

3. The flying machine must be designed to carry two persons having a combined weight of about 350 lbs., also sufficient fuel for a flight of 125 miles.

4. The flying machine should be designed to have a speed of at least 40 m.p.h. in still air, but bidders must submit quotations in their proposals for cost depending upon the speed attained during the trial flight, according to the following scale:—

40 m.p.h.	... 100 per cent.	41 m.p.h.	... 110 per cent.
39 ,,	... 90 ,,	42 ,,	... 120 ,,
38 ,,	... 80 ,,	43 ,,	... 130 ,,
37 ,,	... 70 ,,	44 ,,	... 140 ,,
36* ,,	... 60 ,,		

* Less than 36 m.p.h. rejected.

5. The speed accomplished during the trial flight will be determined by taking an average of the time over a measured course of more than five miles, against and with the wind. The time will be taken by a flying start, passing the starting point at full speed at both ends of the course. This test subject to such additional details as the Chief Signal Officer of the Army may prescribe at the time.

6. Before acceptance a trial endurance flight will be required of at least one hour, during which time the flying machine must remain continuously in the air without landing. It shall return to the starting point and land without any damage that would prevent it starting upon another flight. During this trial flight of one hour it must be steered in all directions without difficulty and at all times under perfect control and equilibrium.

7. Three trials will be allowed for speed as provided for in paragraphs 4 and 5. Three trials for endurance as provided for in paragraph 6, and both tests must be completed within a period of thirty days from the date of delivery. The expense of the tests to be borne by the manufacturer. The place of delivery to the Government and trial flights will be at Fort Myer, Virginia.

8. It should be so designed as to ascend in any country which may be encountered in field service. The starting device must be simple and transportable. It should also land in a field without requiring a specially prepared spot, and without damaging its structure.

9. It should be provided with some device to permit of a safe descent in case of an accident to the propelling machinery.

10. It should be sufficiently simple in its construction and operation to permit an intelligent man to become proficient in its use within a reasonable length of time.

11. Bidders must furnish evidence that the Government of the United States has the lawful right to use all patented devices or appurtenances which may be a part of the flying machine, and that the manufacturers of the flying machine are authorised to convey the same to the Government. This refers to the unrestricted right to use the flying machine sold to the Government, but does not contemplate the exclusive purchase of patent rights for duplicating the flying machine.

12. Bidders will be required to furnish with their proposal a certified check amounting to ten per cent. of the price stated for the 40-mile speed. Upon making the award for this flying machine these certified checks will be returned to the bidders, and the successful bidder will be required to furnish a bond, according to Army Regulations, of the amount equal to the price stated for the 40-mile speed.

13. The price quoted in proposals must be understood to include the instruction of two men in the handling and operation of this flying machine. No extra charge for this service will be allowed.

14. Bidders must state the time which will be required for delivery after receipt of order.

JAMES ALLEN,

Brigadier-General, Chief Signal Officer of the Army.

Signal Office, Washington, D.C., Dec. 23rd, 1907.

APPENDIX No. 2.

SIGNAL CORPS SPECIFICATION, No. 483.

Advertisement and Specification for a Dirigible Balloon.

Bidders are requested to read carefully every paragraph of this specification and include in their proposal every detail called for.

To the Public.—Sealed proposals, in duplicate, will be received at this office until 12 o'clock noon on February 15th, 1908, and no proposals will be considered which are received after that hour.

Persons wishing to submit proposals under this specification can obtain the necessary forms and envelopes by application to the Chief Signal Officer, United States Army, War Department, Washington, D.C. The United States reserves the right to reject any and all proposals.

Unless the bidders are also the manufacturers of the dirigible balloon they must state the name and place of the maker.

Preliminary.—This specification covers the construction of a dirigible balloon, to consist of a gas-bag supporting a suitable framework on which will be mounted the necessary propelling machinery.

Inspection.—The Chief Signal Officer of the Army will reserve the right to inspect any and all processes of manufacture, and unsatisfactory material will be marked for rejection by the inspectors before assembling.

Acceptance.—The dirigible balloon will be accepted only after a trial flight, during which it will comply with all requirements of this specification.

General Requirements.

The general dimensions of the dirigible balloon will be determined by the manufacturer, subject to the following conditions :—

1. The gas-bag shall be designed for inflation with hydrogen. The material for the gas-bag shall be furnished by the bidder, and shall be subject to approval by the Chief Signal Officer of the Army, and must have a minimum breaking strength of not less than 62½ lbs. per inch width, and must require no varnish. The dimensions and shape of the gas-bag will be as desired by the manufacturer, except that the length must not exceed one hundred and twenty (120) feet.

2. Inside the gas-bag there will be either one or two ballonettes, having a total capacity of at least one-sixth the total volume of the gas-bag. Leading to the ballonettes there will be tubes of proper size, connected to a suitable centrifugal blower for maintaining a constant air pressure in the ballonettes. The approved fabric for the ballonettes must have a minimum tensile strength of not less than 48½ lbs. per inch width.

3. *Valves.*—In the lower part of the ballonette and gas-bag, or on the ballonette air tubes near the gas-bag, there will be an adjustable automatic valve designed to release air from the ballonette to the outside atmosphere. On the under side of the gas-bag there will be a second adjustable automatic valve of suitable size, so designed as to release hydrogen from the interior of the gas-bag to the outside atmosphere. This valve will also be arranged so that it may be opened at will by the pilot.

4. In the upper portion of the gas-bag there will be provided a ripping strip covering an opening five (5) inches wide by six (6) feet long, with a red rip cord attached in the usual manner, and brought down within reach of the pilot through a suitable gas-tight rubber plug inserted in a wooden ring socket.

5. The suspension system and frame must be designed to have a factor of safety of at least three, taking into account wind strains as well as the weight suspended.

6. A type of frame which can be quickly and easily assembled and taken apart will be considered an advantage.

7. The balloon must be designed to carry two persons having a combined weight of 350 lbs. ; also at least 100 lbs. of ballast, which may be used to compensate for increased weight of balloon when operating in rain.

8. The dirigible balloon should be designed to have a speed of twenty miles per hour in still air, but bidders must submit quotations in their proposals for cost depending upon the speed attained during the trial flight according to the following schedule :—

20 m.p.h.	...	100 per cent.	21 m.p.h.	...	115 per cent.
19 ,,	...	85 ,,	22 ,,	...	130 ,,
18 ,,	...	70 ,,	23 ,,	...	145 ,,
17 ,,	...	55 ,,	24 ,,	...	160 ,,
16* ,,	...	40 ,,			

* Less than 16 m.p.h. rejected.

9. The speed accomplished during the trial flight will be determined by taking an average of the time over a measured course of between two and five miles against and with the wind. The time will be taken by a flying start, passing the starting point at full speed at both ends of the course. This test subject to such additional details as the Chief Signal Officer of the Army may prescribe at the time.

10. Provision must be made to carry sufficient fuel for continuous operation of the engine for at least two hours. This will be determined by a trial endurance flight of two hours, during which time the airship will travel continuously at an average speed of at least 70 per cent. of that which the airship accomplishes during the trial flight for speed stated in paragraph 9 of this specification. The engine must have suitable cooling arrangements, so that excessive heating will not occur.

11. Three trials will be allowed for speed, as provided for in paragraph 9, and three trials for endurance, as provided for in paragraph 10, and both tests must be completed within a period of thirty days from the date of delivery, the expense of the tests to be borne by the manufacturer. The place of delivery to the Government and trial flights will be at Fort Myer, Virginia.

12. The scheme for ascending and descending and maintaining equilibrium must be regulated by shifting weights, movable planes, using two ballonettes or other approved method. Balancing by the aeronaut changing his position will not be accepted.

13. This dirigible balloon will be provided with a rudder of suitable size, a manometer for indicating the pressure within the gas-bag, and all other fittings and appurtenances which will be required for successful and continuous flights, according to this specification.

14. Bidders will be required to furnish with their proposal a certified check amounting to 15 per. cent. of the price stated for the 20-mile speed. Upon making the award for this airship these certified checks will be returned to bidders, and the successful bidder will be required to furnish a bond, according to Army Regulations, of the amount equal to the price stated for 20-mile speed.

15. Bidders must submit with their proposals drawings to scale showing the general dimensions and shape of the dirigible balloon which they propose to build under this specification ; the horse-power and description of the engine which will be used for the motive power ; the size, pitch, and number of revolutions of the propellers ; drawing illustrating the suspension system for attaching frame to gas-bag ; horse-power and description of blower for forcing air into ballonettes ; volume of gas-bag ; volume of ballonettes ; the material of which the frame will be constructed ; size of valves, &c. Plans received will not be shown to other bidders.

16. Bidders must furnish evidence that the Government of the United States has the lawful right to use all patented devices or appurtenances which may be part of the dirigible balloon, and that the manufacturers of the dirigible balloon are authorised to convey the same to the Government. This refers to the right of the Government to use this dirigible balloon without liability for infringement of other inventors' patents. It does not contemplate the exclusive purchase of patent rights for duplicating the airship.

17. The prices quoted in proposals must be understood to include the instruction of two men in the handling and operation of this airship. No extra charge for this service will be allowed.

JAMES ALLEN,
Brigadier-General, Chief Signal Officer of the Army.

Signal Office, Washington, D.C., January 21st, 1908.

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Frankfort Exhibition Prizes.

A PRIZE of 10,000 marks has been offered by the town of Wiesbaden for the dirigible which flies between Frankfort and that town, while a prize of 1,500 marks has been founded in Hamburg for the aeronaut who during the Exhibition makes the greatest number of flights over the city. The German Aerial League have promised a donation of 2,000 marks, and Mr. Henry Budge, of Hamburg, has offered to provide a prize of 1,000 marks. A sum of 6,500 marks will be used as a prize fund for a competition for hangars for dirigibles.

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CORRESPONDENCE.

AERODYNAMICS AT THE POLYTECHNIC.

To the Editor of FLIGHT.

SIR,—It will probably interest you to learn that as a consequence of the interest shown in my two lectures on the aeroplane by the engineering students of the Regent Street Polytechnic, it has been decided to establish a regular course of aerodynamics at the Polytechnic.

This course, which will be made as experimental and as practical as possible, will commence with the session 1909–10, in September next.

The course of lectures will be delivered by me in connection with Professor Spooner's course of motor engineering, and, in this way, all the different questions connected with aerial navigation will be considered.

Yours very truly,
L. BLIN DESBLIDS.

BRITISH INVENTIONS AND FOREIGN ENCOURAGEMENT.

To the Editor of FLIGHT.

SIR,—In the correspondence of FLIGHT of May 8th, Mr. Charles D. Clayton's letter is of great interest to me, and there is no doubt to several others, concerning encouragement of British inventions on aerial machines, and that there are a great many would-be fine inventions put aside, or otherwise let drop, owing to the lack of British enterprise and financial difficulties. I know of at least two besides myself who have been experimenting with flying machines other than aeroplanes, mine being one of flapping wings principle, which I have also been flying as a kite, and had the wings, four in number, flapping without engine, which increases the lifting powers a great deal, also lifts the machine from where she stands without starting rail or bogie, or the like; but I am in the same place as the others, no doubt several, which I think could be helped out of difficulties one way or another, and wishes to make one suggestion, which I am of opinion would be a great success, and that is, we will say that at the next Aero Show there should be a selling class for models—*working models* I should say—and be classed for sale as to the awards they receive.

Yours truly,
Colne. W. S. PETTY, Jun.

A LIGHT 25-H.P. ENGINE WANTED.

To the Editor of FLIGHT.

SIR,—I have read your paragraph in your issue of the 13th inst. upon this subject. I am afraid it would be very difficult to get an English manufacturer to assist anyone who is constructing an aeroplane by lending or hiring an engine.

Unfortunately for us, Britishers will not take sporting risks, although they are ready to buy a half share in any successful business for about a twentieth part of what it may be worth.

I am in similar position to your correspondent, as I have an aeroplane about half finished and am obliged now to proceed slowly as my capital is becoming low.

I have purchased a 25–30-h.p. French engine, and now I have to sell it at a loss or practically give it away, as of course I must have an English one.

I have many personal friends in the motor industry, and I approached one the other day with the same object as your correspondent, and I was all but promised an engine, but alas, by the next post I received a letter regretting that, owing to pressure of work, the firm could not spare one.

I am doing the very best work and on the very best lines, and I am hoping to be able to get my machine finished in time to compete for some of the prizes now available.

Would that I could get capital to expedite matters or preferably a worker like myself with capital.

S.

WRIGHT BROTHERS' FLYER, &c.

To the Editor of FLIGHT.

SIR,—I should like to answer a few questions raised in your paper.

Mr. Gaunt asks the question, what is the cause of W. Wright's undulating motion as shown on the cinematograph? This I noticed myself, and also noticed the same thing when I saw him fly at Le Mans last October. The reason I have found from experiment with models, is because of pockets or rarified stratas in the air, coupled with the motion of his flexible wings, for when the aeroplane is passing over these pockets the air strikes the wings at different strengths, causing the aeroplane to lift in a series of jumps. This I find does help the machine in flight, giving it a gliding motion on the downward impulse, which releases pressure somewhat on the propellers, and causes engine to race, and in doing so whirls the propellers faster, which causes machine to be pushed on at a greater speed, and so lifts aeroplane on a higher level. This, coupled with the drag of the flexing wings, is, in my opinion, the reason of the wavy motion in flight. Mr. Hare's remarks *re* broadside-on flight proves he has never noticed "how" a bird flies.

I do not hold with Mr. Holdsworth's argument *re* capitalists in this country. I have never seen them, nor heard of them, falling over one another in such eagerness to finance anything that was not pushed down their throats.

Take Mr. W. Wright, for instance. No one would believe in his success until he compelled them by sheer weight, not of "proof" but "profit."

I have designed an aeroplane, and patented same, which I can prove would be superior to any existing machine now made, and if Mr. Holdsworth can find me a capitalist willing to speculate £850 on a trial machine, I shall be quite willing to submit my design to any expert the capitalist would be willing to name before he expended a penny of his money. My method of balance is nearer to the same used by birds than any machine which has yet been made.

Yours truly,
C. P. FOSTER.

MOTORS FOR MODELS.

To the Editor of FLIGHT.

SIR,—In reply to Mr. A. R. Angus's letter in your last issue concerning motors for model flyers, I should hardly consider the phonograph clockwork as suitable as, say, the works of a cheap clock. In the former the wheels are usually controlled by governors, weighing anything from eight to twelve ounces, which obviously could not be included on a model, and without which the spring would relax in a very short space of time, while in the latter the works are regulated by a considerable number of cog-wheels, and thereby obtain a much greater speed, which, after all, is the chief feature in driving a propeller.

Yours truly,
Luton. G. B. JENKINS.

To the Editor of FLIGHT.

SIR,—In reply to the question of Mr. Athol Angus in FLIGHT, May 15th.

A phonograph motion is very much too heavy. I should advise Mr. Angus to first study the relation of surfaces, speed, and weight-carrying capacity, next study the amount of power or drift required to drive surfaces and weights through the air, after this study the number of foot-lbs. of power produced by a given weight of steel spring, and finally study the balance of aeroplanes in flight. He may then be in a position to proceed to model building without the waste of money or energy, and get some satisfactory results.

I shall be pleased to answer any questions which Mr. Angus may like to ask, and hope that my letter will not offend him, but be of some value to him with regard to procedure before making models.

Yours very truly,
Stoke Newington. MONTFORD KAY.

FLIGHT.

44, ST. MARTIN'S LANE. LONDON, W.C.

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